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SOME OBSERVATIONS ON RORQUALS OFF SOUTHERN NEWFOUNDLAND.

GLOVER M. ALLEN.

UNTIL very recently it has been the usage, in books on natural history, to picture Cetacea, when in their native element, as floating lightly on the surface of the water and sending forth from the blow-holes great columns of spray which break and fall in showers over the back. In the works of the older writers, as Bonnaterre and Lacépède, the spouts of whales are represented as solid columns of water, of nearly uniform diameter throughout, which after reaching their maximum height, curve over, either to the front or to the rear, and, breaking slightly, vanish away. Such representations, however, were recognized as entirely inadequate, being merely the conventional vagaries of the artists. K. E. von Baer ('64) seems to have been among the first to attempt an accurate delineation of the whale's spout. He figures a Finback whale in the act of "blowing," the column being a vertical one, expanding very slightly until the maximum height is reached, when it bushes out and gradually becomes dispersed. Henking (:01) also represents in a very diagrammatic way his impression of the form of a Finback whale's

spout. The outline he makes retort-shaped, and the whole is directed slightly backward. Both these authors add that their observations were made in calm weather with a smooth sea.

Not until 1903 have there been published any actual photographs of the larger whales alive and free in the open ocean. The first published photographs of this nature appear in the report on the Cetacea of the Antarctic expedition of the "Belgica." These represent the Humpback whale (*Megaptera nodosa*) and the Sulphur-bottom (*Balænoptera musculus*) in the various positions assumed during their appearance at the surface of the ocean, and were taken by Dr. E. G. Racovitza and Dr. F. A. Cook, in 1898. Only one view is shown of the spout, and this is so indistinct as to be rather unsatisfactory. Later in the year 1903, Dr. F. W. True (:03[a]) published some very excellent photographs of Finback whales (*Balænoptera physalus*) taken from the bow of a whaling steamer off the east coast of Newfoundland. These views show very well the appearance of this whale in its various postures following the spouting, until its final plunge. No photograph of the spout itself was obtained, however, so that it seems worth while to publish a few views of spouting whales obtained by the present writer a few months ago.

Through the courtesy of Mr. Alexander McDougall, manager of the Newfoundland Steam Whaling Company, I had the privilege of visiting the whaling station at Rose-au-Rue, in Placentia Bay, Newfoundland, during the second week of September, 1903. A number of interesting observations were made at this time and a valuable series of photographs was secured, some of which are reproduced here.

Four species of rorquals are taken on the Newfoundland coast: the Humpback (*Megaptera nodosa*), the Sulphur-bottom (*Balænoptera musculus*), the common Finback (*B. physalus*), and the Pollack whale (*B. borealis*) or, as the Norwegians call it, the "Sejhval." True (:03) was the first to record the presence of the last named species on this side of the Atlantic, on the basis of four specimens taken at the Rose-au-Rue station during the season of 1902. The steam whaling industry at Newfoundland is one of recent origin, having been established in 1898. Accord-

ing to the *Morning Chronicle*, of Halifax, N. S., the amount of whale oil produced in Newfoundland for the fiscal year ending June 30, 1902, was valued at $125,287. In addition to the oil which is tried out from the blubber and carcass, an excellent "guano" is prepared from the refuse flesh and the bones are ground up into lime.

The fishery itself is carried on by means of small and staunchly built iron steamers of something over one hundred tons. A cannon-like gun is mounted on a pivot at the bow, and discharges a five-foot harpoon of over 100 pounds weight, which at short range is nearly buried in the body of the whale. A hollow, iron cap filled with blasting powder is screwed to the tip of the harpoon, forming its point. A timed fuse discharges this bomb inside the body of the whale. The harpoon carries a stout cable which is handled by a powerful 5-sheet winch on the steamer's deck.

On September 9th the writer accompanied the whaling steamer "Puma," Captain Christaffersen, on the daily hunt in the lower part of Placentia Bay, and obtained several successful photographs of living whales at close range. A few of these are here reproduced, and illustrate particularly the spout of the Sulphur-bottom whale (*Balænoptera musculus*), no photograph of which has hitherto been published, with the exception of the one by Racovitza.

Both Finback and Sulphur-bottom whales observed on this occasion seemed to go through a regular series of evolutions, and were doubtless feeding. They rose to spout about once in every 12 to 15 seconds with great regularity for perhaps twelve times, after which they dove for a much longer stay of several minutes. The precise length of the longer periods was not accurately determined, but could hardly have been more than 5 or 10 minutes. On rising, the first part of the animal to reach the surface is the top of the head; at the same time it spouts, and a portion of the long back comes into view. The head is then lowered, the body arches slightly and the descent begins. The back comes curving out of the water and down again, till finally the dorsal fin appears. By the time the fin has reached the surface again in its forward and downward move-

ment the entire body has disappeared. The flukes were not thrown out of water by either of the two species seen alive, as has been noted by True and others.

The whale, in diving, leaves a long "slick" on the water at the spot where it went down, and comes up again in regular course several times its length farther on when making a series

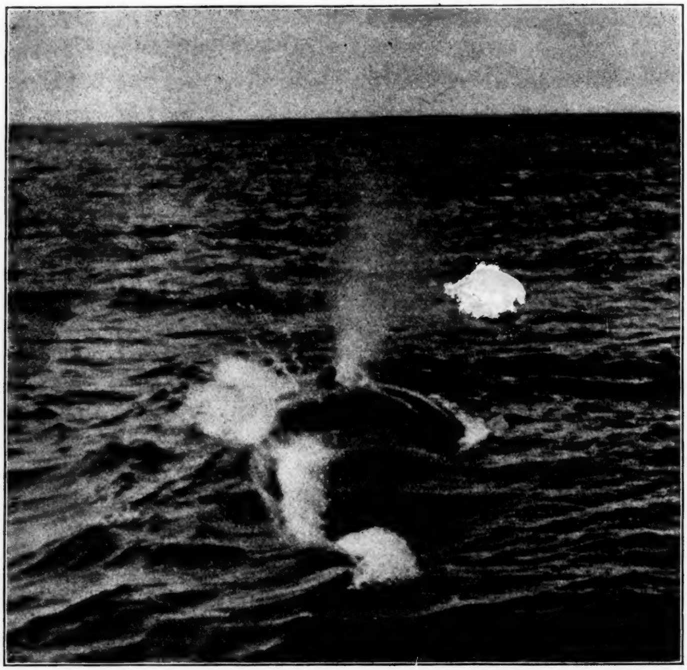

FIG. 1.— A sulphur-bottom whale spouting.

of "spouts" or breathings. The distance between successive spouts seemed to be nearly two or three times the length of the whale, *i. e.*, 150 to 200 feet.

When a whale is sighted the steamer is put about to overtake it, but the endeavor seems to be not so much to head it off as to cut in behind so as not to unduly frighten the animal. On overtaking the quarry, the steamer is manœuvered so as to come

to a stop at about the spot where the whale is expected to rise for the next spout. On one occasion a Sulphur-bottom was thus followed for a considerable distance till finally the vessel came to a standstill at about the place where the next appearance of the animal was expected. The distance had been well judged, and the writer, standing with camera ready, was able shortly to perceive the shadowy form rising obliquely under the port bow. As the whale broke water and shot forth a column of vapor, the click of the camera and the crash of the harpoon gun sounded almost at the same instant. The photograph obtained (Fig. 1) shows the Sulphur-bottom with the region of the blow-holes just

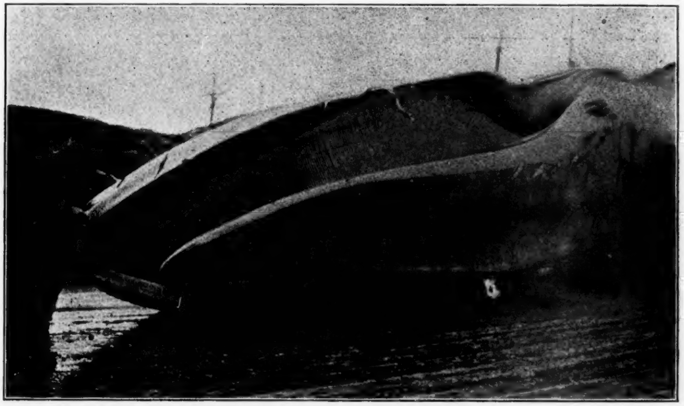

FIG. 2.— Head of a sulphur bottom from above.

out of water. The spout itself was a very short one and is seen to have somewhat the form of a narrow, inverted flask. The wind, blowing from left to right of the picture, carries the upper portion of the vaporous stream away to leeward. The most interesting feature of this view is that the area at each side of the blow-holes is clearly seen to be elevated above the apertures themselves as the breath escapes. The elevation of these ridges is well shown in side view among the photographs obtained by True (:03[a]), and in the drawings by Racovitza (:03), but neither of these observers was able to determine satisfactorily whether it was the blow-holes themselves, or only

the adjacent parts, that were thus raised. In the view here shown, which was taken from directly behind the animal's head, there can be no doubt that the portion elevated in spouting is the region lying along the external side of each nasal aperture. The broad, shallow groove or depression extending downward from each side of the blow-holes may possibly be due to the muscular contraction incident to the raising of the two ridges. The same feature in side view is possibly shown in one of the photographs by True (:03, Pl. 25, Fig. 2). No such groove was seen in the dead specimens. The column of vapor itself is clearly single, even though arising from two apertures, for the latter are situated so close together that the two jets

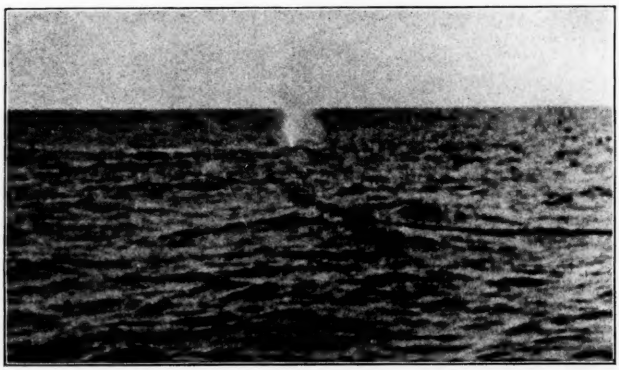

FIG. 3 — Spout of a sulphur-bottom.

of vapor must unite at once. The photographs do not, therefore, bear out Packard's ('66, p. 272) statement, on the testimony of another, that the Sulphur-bottom blows in a "double stream which is directed backward toward the tail." The blowholes of a large whale of this species are represented in Figure 2. The animal lies on its left side with the upper surface of the head toward the observer. The mouth is partly open, and from it projects the fringe of baleen. The two slit-like nasal openings are seen near the lower right hand of the figure and appear to be situated between the arms of a V-shaped prominence whose point is directed forward, and is continued as a slight

median ridge toward the tip of the snout. In the dead animal, however, there is hardly more than this slight suggestion of the nasal ridges which are so prominent in life.

The form of the spout, in both the Sulphur-bottom and the Finback whale, unless distorted by the wind, is that of a simple column, narrow at the base and gradually increasing in diameter with the height, like a jet of steam forced through a small opening. Such a spout is shown fairly well in Figure 1, Plate 1, of Racovitza's (:03) paper. The views obtained by the present writer all show the effect of the light wind blowing at the time, in that the vapor is carried off to leeward to a greater or less

Fig. 4.— An irregular spout of a sulphur-bottom.

extent. Figure 3 shows the spout of a Sulphur-bottom which is fast by a line to the whaling steamer. This view shows the general outline of the column, with a slightly rounded top. Figure 4 shows a spout of an irregular outline from the same whale at closer range. The two harpoon lines by which it is fast to the vessel are seen at the lower right hand. The top of the column is of thin vapor and is being wafted away by the breeze. The lower part of the column is much denser and somewhat in the form of an inverted cone. Possibly the irregular shape may be in part due to a slight wave breaking over the animal's head as it commenced to spout.

The height to which the larger rorquals spout varies consider-

ably according to circumstances. The same individuals are seen at times to make a low spout and again, one twice or perhaps thrice as high. Estimates of the height of the column by seemingly reliable persons run from ten feet up to fifty. It is sometimes stated (*cf.* Beddard, :00, p. 153) that the Sulphur-bottom whale may be recognized by the great height of its spout as compared with that of other large species of rorquals. The writer was unable, however, to distinguish between the spouts of the Finback (*Balænoptera physalus*) and the Sulphur-bottom whale (*Balænoptera musculus*), nor did the men on the whaling

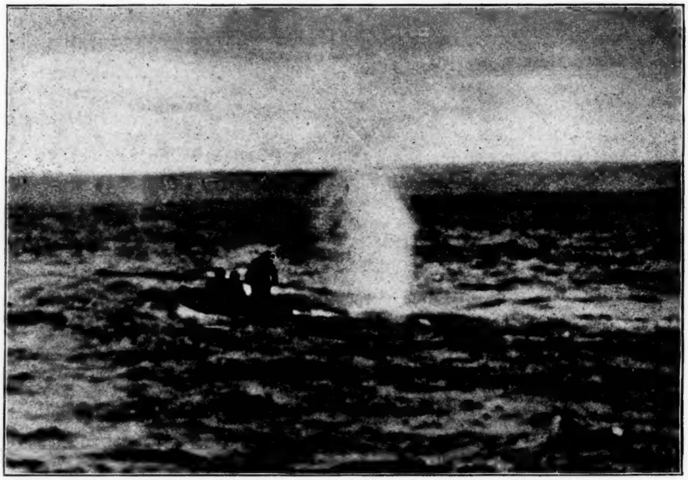

FIG. 5.— Lancing a spouting sulphur-bottom.

vessel believe that the height of the spout afforded any criterion for such a distinction. One of the photographs obtained by the writer, however, affords an opportunity for the direct comparison of the relative heights of a man and of the spout of a whale. Figure 5 shows the captain in the act of lancing a 77-foot Sulphur-bottom which two harpoons had failed to despatch. He stands in the bottom of the boat, alongside the exhausted animal, and the spout, extending up to the skyline in the photograph, is one of average height. The standing height of the man is about

5 feet 8 inches, and the height of the spout is $2\frac{1}{3}$ times as great, or about 14 feet. A maximum spout would probably be close to 20 feet high, which is the estimate I find in my notes taken at the time.

I had no means of accurately estimating the speed at which these whales travel through the water, but it not infrequently happens that the whaler, steaming at ten knots an hour, is unable to overtake a free whale even after a considerable chase. Beddard's statement that the maximum speed of a Sulphur-bottom whale is in the neighborhood of twelve miles an hour is

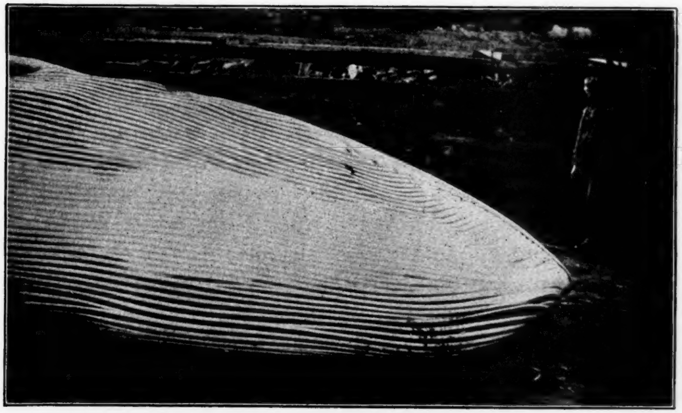

Fig. 6.— Throat of a finback whale.

therefore probably not far from the truth. The ordinary rate of swimming, however, is apparently a little less than this.

During my short stay at the Rose-au-Rue station six whales were taken and all were males. The men told me that at that season (September) the females seek the shallow and more quiet waters of the bays to bring forth their young, and their shyness at this time renders it difficult to approach them. Shortly before my arrival, at about September 4th, a female Finback whale (*Balænoptera physalus*) was killed which contained two calves nearly ready to be brought forth. They were said to have been male and female, about twelve feet long, and were

lying side by side in the uterus with the head of one by the tail of the other. This was the first time that a whale containing more than a single fœtus had been taken by the Company's steamers.

In addition to the photographs of spouting whales it seems worth while to introduce one showing the throat folds. These are usually represented in drawings as simple longitudinal plicæ. Figure 6 represents the ventral side of the throat in a Finback whale (*Balænoptera physalus*). The folds are seen to start from the border of the lips as single plications, but as the expanse of the throat increases posteriorly they fork dichotomously in a fairly definite manner, so that the number of folds at a given part of the center of the throat is greater than that at either end of the corrugated area. Posteriorly the folds run together in reverse order, so that a reduction is effected similar to that found at the anterior region of the throat. Curiously, however, forking may take place in either direction, so that the two new branches may point either anteriorly or posteriorly, but the latter mode of branching was not noticed in the posterior part of the area covered by the folds. Sometimes, also, two folds running parallel to each other may be connected by a short cross-fold, which aids in binding all together.

Up to the time of my visit the whaling steamer *Puma*, operating at Chaleur Bay and at Placentia Bay, had taken in 1903 107 Sulphur-bottoms, 66 Finbacks, 14 Humpbacks, and 1 Pollack whale (*B. borealis*). The last named was captured in Placentia Bay, as were the four taken in 1902.

BIBLIOGRAPHY.

von Baer, K. E.

'64. Noch ein wort über das blasen der Cetaceen, mit bildlichen darstellungen. Bull. de l'Acad. imp. des sci. de St. Pétersbourg, vol. 7, col. 333–341, 3 text figs.

Beddard, F. E.

:00. A Book of Whales. New York. 8vo, illus.

Henking, H.

:01. Ueber das blasen der wale. Zool. anzeiger, vol. 24, p. 103–111, text fig. 1–2.

Packard, A. S.

'66. List of Vertebrates observed at Okak, Labrador, by Rev. Samuel Weiz, with Annotations. Proc. Boston, Soc. Nat. Hist., vol. 10, p. 264–277.

Racovitza, É. G.

:03. Cétacés. Résultats du voyage du S. Y. Belgica, Zoologie., 142 pp., 4 pls. Anvers : 4to.

True, F. W.

:03. First Record of the Pollack Whale (*Balænoptera borealis*) in the Western North Atlantic. Science, n. s., vol. 17, no. 421, p. 150.

True, F. W.

:03a. On some Photographs of Living Finback Whales from Newfoundland. Smithsonian Miscell. Collections, vol. 45, p. 92–94, pl. 24–26.

PHYSICAL IMITATIONS OF THE ACTIVITIES OF AMŒBA.

H. S. JENNINGS.

PHYSICAL imitations of the activities of lower organisms, such as are given us by Bütschli and Rhumbler, have always taken a place among the "startling achievements" of science. They arouse a lively interest in the popular mind as well as in the minds of men who are seriously studying the problems which such activities present. Anything which promises a bridge from the inorganic to the organic, from the physical to the vital, demands attention. Almost all men have definite convictions as to the relation of these two fields, — convictions which are foundational for the whole superstructure of intellectual or religious life; anything which touches these convictions must awaken interest.

How far have the physical imitations of vital activities gone? What do they really show as to relation of physical and vital? In the present paper such physical imitations as relate to one of the lowest organisms, Amœba, will be examined with these questions in view. The greater number of the physical experiments relate directly to Amœba, attempting to imitate its behavior. The writer has recently made a thorough re-examination of the behavior of this animal, the results of which have been published elsewhere (Jennings, :04), so that opportunity is presented for a comparison between the imitations and the reality. By determining to what extent the physical imitations throw light on the behavior of Amœba, we shall perhaps have a fair measure of what has been accomplished in this way, and of the promise for the future.

What is the real purpose of the physical imitations of vital activities? Clearly, the final purpose is to show what physical factors are at work in these activities. But this end may be followed in many ways; what is the special purpose of the imitations?

In the best cases the physical imitations arise as follows: There is first a study of certain vital activities. This is followed by construction of a hypothesis as to the nature of the factors at work, — an explanation of the activities in terms of phenomena already known. The third step is to determine by experiment whether the supposed known factors can produce such activities; these factors are combined in appropriate ways and the results observed. If they bring about activities similar to those shown in the vital phenomena, then the explanation gains much in probability, and we have an "imitation" of the vital activities. What the imitation shows is then, as Rhumbler ('98, p. 108) has well said, that the factors assumed to be at work really can produce such activities as we attribute to them, — and this is a long step in advance. There still remains the question whether the factors in our imitation actually *are* those at work in the vital phenomena.

To enable us to judge intelligently on this final question we need an accurate knowledge of the phenomena to be explained and of the forces at work in the imitation, that they may be closely compared; imitations founded on external resemblance are likely to be misleading. We have indeed three factors to be compared, — the explanation as it exists in the mind of the investigator, the physical experiment, and the vital activity. In the best cases these three must agree; the explanation fits the experiment, and the experiment is essentially similar to the vital phenomenon, so that the explanation fits the latter also. But the explanation given may fit the physical experiment and not the vital activity, or it may not even fit the experiment; we shall find examples of both these cases.

In the commoner case, where the explanation given does fit the physical experiment, how are we to judge whether the vital activity is to be similarly explained? Evidently an explanation based on an imitation can at best fit the vital activity only in so far as the latter agrees with the imitation. Points in which it does not agree must be attributed to other factors, and if these points are essential ones for the explanation given, then we must conclude that the vital activity is not explicable in the way proposed. Further, we must determine whether certain conditions,

preceding or following, which the explanation requires are actually fulfilled in the vital phenomena.

Imitations of the movements and of the variations in form have been oftenest attempted. Almost without exception the imitations are based on the hypothesis that these phenomena in Amœba are due to local changes in the surface tension of a fluid mass. Among the earliest experiments of this sort were those of Gad ('78). Gad placed drops of rancid oils (oils containing fatty acids) in weak solutions of alkali; for example, cod liver oil in 0.2 to 0.5 % sodium carbonate. As a result of the reaction between the fatty acid and the alkali soap is produced. This lowers the surface tension of the drop of oil here and there; as a result the drop changes form, sending out projections having an external resemblance to the pseudopodia of Amœba. A number of figures showing the forms taken by oil drops under these conditions are given in *Verworn's General Physiology.* Gad pointed out the resemblance of these forms to those shown by Amœba, but did not carry the matter farther.

Quincke ('79, '88) pursued further the study of movements caused in the manner just described, and put forth distinctly the view that the movements of Amœba (as well as of other protoplasmic masses) are due to similar causes. Quincke found that egg albumen might take the place of the sodium carbonate in the experiments above described; soap is then formed and movements occur as when the alkali is used. He held that Amœba is covered externally by a thin lamella of oil; that albuminous soaps are formed on the inner surface of this, thus decreasing the surface tension, and that the movements and changes of form are due to these changes in surface tension.

Most celebrated of all imitations of amœboid movements are those of Bütschli ('90, '92). Bütschli mixed slightly damp, powdered potassium carbonate with old olive oil, of a certain degree of rancidity, and brought drops of the mixture into water on a slide. (Directions in Bütschli, '90.) After standing twenty-four hours the drops are washed and new water or glycerine supplied. The drops now show streaming movements, send forth projections (see Fig. 1, *b*), and move about. The external resemblance to the phenomena shown in Amœba is

very striking. The movements are caused as follows: The potassium carbonate is dissolved by the water and acts on the oil, forming soap. Thus after a time the oil drop is permeated throughout by minute globules of soapy water, forming a foam-like emulsion. At times one of these globules of soap bursts on the outside of the drop of oil; the soap then spreads over the surface of the oil, lowering its surface tension in the region affected. At once a projection is formed here, currents flow from within the drop toward the region of lowered tension, and the entire drop may move in that direction.

Bütschli held that the movements of Amœba take place in a similar manner. He considers that protoplasm has an emulsion structure similar in a general way to that of the oil drops, — though of course the constituents are not the same. At times the meshwork enclosing the globules breaks at the outer surface of the Amœba, allowing some of the enclosed fluid to spread over the surface. This lowers the surface tension, causing Amœba to move in the same manner as the drop of oil.

Bütschli is inclined to attach much significance to the fact that the oil drops which move in the way described have a foam-like emulsion structure, and to consider this as a support to his view that the similarly moving protoplasm is similarly constituted. But such movements are by no means specially characteristic of fluids having a foam-like or emulsion structure; many drops having this structure do not show the movements, while other drops which have not this structure show the movements equally well, as we shall see. The movements require only that there shall be some method of producing local changes in surface tension; this may be easily brought about without the emulsion structure.

Bernstein (:00) produced similar movements in drops of mercury. Sufficient mercury to make a drop or disk five to ten millimetres in diameter is placed in a flat-bottomed watch-glass. Over it is poured some 20% nitric acid, and thereto is added a quantity of a strong solution of potassium bichromate. The mixture acts chemically on the mercury, lowering its surface tension. The intensity of the action varies locally, so that the surface tension is decreased now here, now there. As a result

the mercury moves and changes form in a striking manner, sending out projections or becoming wholly irregular, at the same time moving from place to place.[1]

The present author (:02) has given another method of observing such movements. A mixture of three parts glycerine and one part 95 % alcohol is placed on a slide and covered with a large cover-glass, supported near its ends by glass rods. Beneath the cover-glass a drop of clove oil is introduced by means of a medicine dropper drawn to a fine point. The alcohol acts locally on the surface of the clove oil, decreasing its surface tension here and there. As a result the clove oil drop changes form, sends out projections and moves from place in a striking manner. The phenomena shown are similar to those in Bütschli's drops of oil emulsion. The experiments are much easier to perform than those of Bütschli; by varying slightly the amount of alcohol in the mixture one can always be certain of getting marked results. But the movements do not continue so long as in Bütschli's experiments.

In all these experiments the movements are due to local changes in surface tension. When such a local change is produced on the surface of a fluid drop a characteristic set of currents results. From the region of least tension surface cur-

[1] The attempts of Herrera to imitate protoplasmic movements read almost like a travesty of those of the authors above mentioned. Herrera made a "synthetic protoplasm" by mixing together certain chemicals which analysis showed to exist in the protoplasm of one of the myxomycetes. This mixture contained "pepsine, ... peptone, acetic fibrine, oleic acid, soap, sugar, extract of bile, a considerable quantity of carbonate of soda, carbonates of calcium and ammonium, lactate of calcium, phosphates of calcium and magnesium, sulphates of calcium and iron, chloride of sodium, soap" (Herrera, '98, p. 118). When this miscellaneous conglomeration of chemicals was wet with water it showed, as one may well conceive, many diffusion currents. Herrera considers these as a "faithful reproduction of the internal movements of protoplasm described by Van Tieghem." In a later contribution Herrera ('98a) gives an imitation of amœboid motion based on the theory that Amœba is moved by the bubbles of carbon dioxide which it gives off in its respiration. Mix bicarbonate of soda with printer's ink so that a product is obtained having a sirupy consistency. Place on a surface wet with a weak solution of tartaric acid. Bubbles of carbon dioxide are produced, of course causing the mass to change form and move; "the illusion of a living being is complete." It is only just to say that Herrera later gave up the idea that the movements of Amœba are caused in this manner.

rents pass in all directions, while an interior current passes toward the region of least tension. The reason for these currents may be seen by imagining that the drop is covered with a stretched India rubber membrane in place of the surface film. If this stretched membrane is weakened or cut at a certain point the remainder of the membrane will pull away from this point, simulating the surface current. At the same time fluid from within will be pressed out at the weakened point, — thus simulating the central current toward the point of least tension.

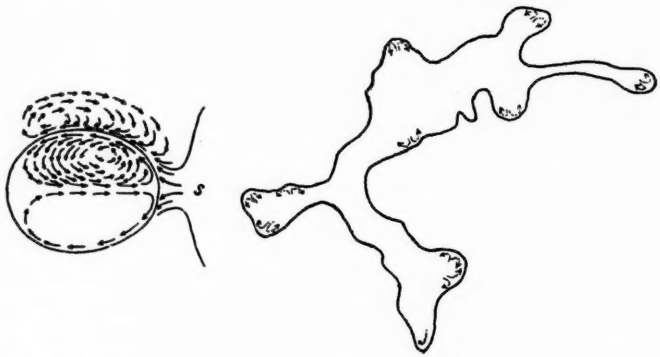

FIG. 1 *a*. FIG. 1 *b*.

FIG. 1.— Currents produced by local decrease of surface tension, after Bütschli. *a*, Currents in an oil drop when the surface tension is decreased at one end by contact with a soap solution (*s*); surface currents away from the point of lowered tension; a central current toward this point. *b*, One of the drops of oil emulsion, showing the irregular form and the characteristic currents at the tip of each projection.

The characteristic currents may be seen in Bütschli's experiments or in those with the drops of clove oil, if some soot or India ink has been mixed with the oil. Such currents are represented in Fig. 1, taken from Bütschli. If the axial current carries forward more fluid than the superficial currents carry backward, the drop may elongate in the direction of the axial current and move as a whole in the same direction. This often occurs.

Such currents as are shown in Figure 1 are an invariable feature of movements of fluids due to local decrease in surface tension. Indeed, these currents are the characteristic phenomena ; they may be the only movements that occur.

If, then, the movements of Amœba are really produced as they are in the imitations, by means of local changes in surface tension, we must expect to find in Amœba these characteristic currents. In an Amœba moving in a certain direction there should be a central current forward and superficial currents backward. In an extending pseudopodium the central current should be toward the point, the superficial currents away from it. Do such currents exist?

There is evidently a central current forward. But are the superficial currents backward, as the theory requires? In studying the movements from above, without the aid of experiment, it is difficult to determine this point. But there are certain appearances on the lower surface and at the lateral margins which give the impression that such backward currents may exist. In fact Bütschli, Rhumbler and others became convinced of the existence of such currents. The movements of Amœba were thus brought into full agreement with those of the drops moving as a result of local decrease in surface tension. This is brought out clearly by an examination of the figures of the currents in Amœba given by Bütschli and Rhumbler, copied in Figure 2. It was then almost inevitable to conclude that the same causes are at work in the two cases; that the movements of Amœba are due to local changes in surface tension.

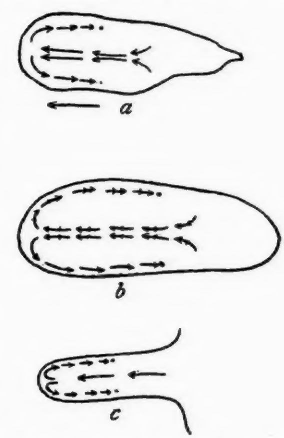

FIG. 2.—Diagram of currents in a moving Amœba, according to Bütschli and Rhumbler. *a*, Diagram of the currents as seen from above, after Rhumbler; *b*, diagram of the currents in side view, after Rhumbler; *c*, diagram of the currents in an advancing pseudopodium, after Bütschli.

In the extended experimental study of the activities of Amœba recently made by the present writer (:04), it was shown that the supposed backward currents of the surface do not exist. On the contrary, all parts of the surface which are not attached to the substratum are typically moving forward, in

the same direction as the central current, while the attached parts of the surface are at rest. The movement of Amœba is thus of a rolling character; the upper surface continually passes around the anterior end to form the lower surface; this then remains quiet until it is taken up by the posterior end as the latter moves forward. The movements in an advancing Amœba are indicated in Figure 3. In a projecting pseudopodium the movements are of the same character as those at the anterior end (Fig. 3), save when the pseudopodium projects freely into

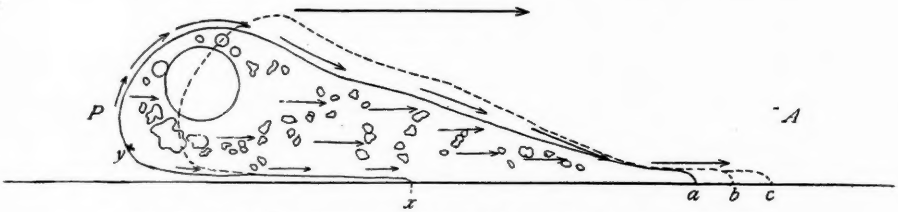

FIG. 3.— Diagram of the movements of an Amœba in locomotion, side view. The arrows show the direction of the currents; the longer arrows indicating more rapid movement. The large arrow above shows the direction of locomotion. The anterior end (A) is thin and attached to the substratum as far back as *x*; the lower surface from *a* to *x* is at rest. The posterior end (*P*) is high and rounded, and free from the substratum. *a*, *b*, *c*, successive positions occupied by the anterior end. The broken outline shows the position occupied by the Amœba a little later.

the water, being nowhere in contact with a solid. In the latter case the entire surface moves outward, in the same direction as the tip.

Details of the observations and experiments which demonstrate the movements to be of the character just set forth are given in an extensive paper published elsewhere (Jennings, :04). The movements were determined chiefly by observing the motion of objects attached to the outer surface of Amœba, of objects partly imbedded in the outer layer, and of particles within the body. The movements as thus studied are clear, and exclude the possibility of the typical existence of backward currents on the surface.

It appears then that Amœba does not move in the same manner as do the imitations based on local changes in the surface tension of a fluid mass. The currents which form the characteristic features in the latter case are not present in Amœba.

Neither theoretically nor practically does there appear to be any evidence that movements due to changes in surface tension can take place without these characteristic currents. We cannot then consider the movements of Amœba to be due to a decrease in surface tension at the anterior end, as in the "imitations." In precisely the feature which led to the supposition that the movements in the two cases were of the same character we find that there is actually an absolute contrast. In Amœba the surface currents are in the direction of movement of the mass, and in the same direction as the central current; in the imitations they are in the opposite direction.

Clearly the surface tension theory will not account for the phenomena as they actually exist. This becomes still more evident when we consider the formation of pseudopodia not in contact. In these there is not only no backward current, but also no resting surface; axis and surface move outward in the same direction as the tip. Such movements are not producible by local changes in surface tension. The "imitations" are imitations only to the extent that they are fluids and that they move; they are not imitations so far as the nature of the movements and their cause is concerned.

A much more nearly accurate imitation of the movements of Amœba may be produced with gravity as the active agent in place of surface tension. A drop of water moving down hill on a surface to which it does not cling strongly shows the same rolling movement that we find in Amœba. The lower surface (in contact with the substratum) is at rest, while the upper surface moves forward and passes continually around the anterior end to the lower surface. But we know that gravity is not the active agent in the movement of Amœba.

An imitation of the usual locomotion of Amœba that is accurate even to minute details is described by the present author in the paper on the behavior of Amœba already cited (Jennings :04). A drop of fluid resting on a substratum is caused to adhere to the substratum more strongly at one edge than at the other. Thereupon the drop moves toward the more adherent edge, and in so doing it shows exactly the form and movements of an Amœba in locomotion. The experiments may best be

performed as follows: A piece of smooth cardboard, such as the Bristol board used for drawing, is placed in the bottom of a flat dish and on a certain spot on the cardboard is placed a drop of water. The whole is then covered with bone oil. This soaks into the cardboard, except where the latter is protected by the drop of water. After the board is well soaked in oil the drop of water is removed, leaving the whole surface covered with oil some millimeters deep. Now a drop of water or glycerine, to which has been added some fine soot, is placed on the cardboard under the oil. This drop is allowed to come in contact by one edge with the area which had been protected from the oil. To this area it adheres, the edge in contact spreads out as a thin sheet, and the rest of the drop is pulled over to the area. Its movement is then exactly that typical for a flowing Amœba, so that Figure 3 would do equally well for a diagram of the movements of such a drop as for those of Amœba. The resemblance extends to minute details; many of these are set forth in the author's paper above cited (:04). Among other things, the formation of pseudopodia in contact with the substratum may be imitated by making the area to which the drop adheres at one edge very small; then a projection is formed merely of the width of this area.

But this imitation, like the others, fails when we take into consideration the formation of pseudopodia which are nowhere in contact with a solid. Projections corresponding to these cannot be formed in the physical experiments just described, for in these adherence to a solid is the essential point. Since the entire anterior end of the Amœba can be pushed out into the free water, we find that Amœba can perform all the active operations concerned in locomotion without adherence to a solid. This effectually blocks any attempt to explain the movements of Amœba as due, like those of the drops in the experiments just described, to one-sided adherence to the substratum.

Thus none of the physical imitations gives us a clue to the physical agent actually at work in the movements of Amœba. The experiments last described are perhaps useful in giving us an idea of the direction of action of the forces at work in producing locomotion. Not even so much as this can be said of

the surface tension experiments; the direction of action of the forces in these is evidently different from that in Amœba.

We may then turn to imitations of other activities of Amœba. Many attempts have been made to imitate certain of the reactions to stimuli — particularly the positive reaction to chemicals. Such imitations depend on the fact that a local decrease in the surface tension of a drop of fluid may be caused by contact with a chemical; the drop then moves in the direction of lowered tension. Some of the experiments based on this are the following:

Rhumbler ('99, p. 585) placed a small drop (60 to 90 μ in diameter) of castor oil in alcohol, and brought close to it the open end of a capillary tube containing clove oil, chloroform, or 5 % potassium hydroxide. The substance within the tube diffused out against the drop of castor oil and decreased its surface tension in the region of contact. Thereupon the usual currents were produced (Fig. 1), and the drop moved in the direction of lowered tension, finally entering the tube.

Bernstein (:00) placed a drop of mercury in twenty per cent. nitric acid, then brought near it a crystal of potassium bichromate. By the chemical action the surface tension on the side of the drop next to the crystal is decreased. Thereupon the drop moves rapidly over to the crystal, and may push it about from place to place.

In the drops of clove oil in a mixture of glycerine and alcohol, described above (p. 8), similar movements may be caused (Jennings :02). With a capillary pipette a little alcohol is brought near one side of the drop. This decreases the surface tension of the part affected; thereupon a projection is sent out toward the alcohol, and the drop as a whole moves toward it. If the drop is heated at one edge, by touching the cover glass near it with a hot wire, the clove oil moves toward the heated side, and may be induced to follow the wire for some distance.

In all these experiments the movement is due to local alterations in surface tension; the drop moves toward the region of lowest tension; there is a central current in the direction of locomotion, and surface currents in the opposite direction. In Amœba, on the other hand, as we have seen, the movements

cannot be considered due to local decrease in surface tension. There are no superficial currents away from the region toward which the animal moves, but all parts that are in motion move toward the object causing the reaction. (For details, see Jennings, :04.) The experiments do not imitate the essential features of the action of Amœba, and do not show us the causes at work in its behavior. The reactions of Amœba are not simple direct results of the physical action of the agents producing them, but are indirect, like those of higher animals.

Many imitations have been devised for the taking of food by Amœba. Rhumbler ('98) holds that the ingestion of food by Amœba is due to physical adhesion between the liquid protoplasm and the solid food. He shows that drops of all sorts of fluids take in certain solids in this manner. A drop of water placed at the edge of a plate of glass draws to itself and envelopes splinters of wood and various other solids which come in contact with it. Glycerine, oils, white of egg, gum arabic, mastax varnish, etc., are shown to do the same. A convenient way of showing this is to fill a capillary glass tube with the fluid, then to bring a small piece of the solid in contact with the free surface of the liquid at the end of the tube. The pulling of the solid into the liquid is due to the adhesion of the two, in connection with the surface tension of the liquid.

These experiments of Rhumbler show that food might be taken in this manner, not that it is so taken. Careful study shows that there is in most species of Amœba no adhesion between the protoplasm and the food body. Food is taken by actively enclosing it along with a small quantity of water; the fact that no adhesion exists between it and the protoplasm is strikingly evident, and occasions much difficulty in the ingestion of food. (For details, see Jennings, :04, and compare the similar account of food-taking by Le Dantec, '94.) Thus the experiments do not really imitate the essential features of the behavior in Amœba. Only in Amœba verrucosa and its close relatives is there evidence of adhesion between the animal and its food. But even here there is adhesion equally to bodies which do not serve as food and are not ingested, so that for the ingestion itself an additional factor is necessary.

One of Rhumbler's most striking experiments is an imitation of the method by which Amœba takes as food a long filament of Oscillaria, coiling it up and enclosing it. The Amœba settles down somewhere along the filament, lengthens out upon it, and bends it over, forming a loop. This process is repeated until the long filament forms a close coil within the Amœba (figures in Rhumbler, 1898, p. 211, Lang, :01, p. 39; a similar account with figure in Leidy, '79, p. 86). Rhumbler considers this remarkable process to be brought about as follows: The Amœba adheres to the filament. It lengthens out along it, just as a drop of water lengthens out along a filament to which it adheres. Owing to the surface tension of the fluid protoplasm, impelling it to take the spherical form, it pulls on the two halves of the filament, producing a thrust inward from both directions. Gradually the enclosed parts of the filament are softened in the digestive processes of the Amœba. The softened portion then yields to the thrust from both directions and bends, so that more of the filament can be pulled into the Amœba by the tension of its surface film. The Amœba then lengthens out farther, owing to adhesion; more of the filament is softened and yields farther, so that more is pulled in by surface tension. This process continues until the filament is completely coiled up and enclosed.

On the basis of this explanation Rhumbler devised an imitation of the process. A chloroform drop is placed in the bottom of a watch-glass of water. A long fine thread of shellac, obtained by heating two pieces of shellac in contact over a flame and rapidly pulling them apart, is brought in contact with the drop. The latter envelopes the filament in some portion of its length, then proceeds to coil it up, as Amœba does with the Oscillaria filament; after a time the shellac thread is completely enclosed within the chloroform drop. The mechanism of the process is conceived to be the same as that above given for Amœba and the Alga filament.

This experiment is an interesting example of one of the numerous difficulties which beset the worker along such lines, — of the fact, namely, that even the imitation may not agree with the explanation given. The coiling up of the shellac

thread by the chloroform is not explicable in the manner supposed by Rhumbler; the surface tension of the drop has really nothing to do with it. This is shown by the fact that such a thread of shellac is coiled up in exactly the same manner if submerged in a large vessel of chloroform, so that it is nowhere in contact with the surface film. The coiling up is apparently due to strains within the shellac filament, produced when it was pulled out, and to the adhesiveness of its surface when wet with chloroform. There are no corresponding factors in the Oscillaria thread; this will indeed, as Rhumbler has shown, straighten out again when released by the Amœba. The process by which Amœba coils up the Oscillaria filament must thus be of an essentially different character from that occurring in the experiment. The explanation given by Rhumbler may of course still be correct for the process in Amœba, though it is not correct for his imitation of the process.

Amœba does not ingest every small object with which it comes in contact, but exercises an evident choice as to the substances which it takes as food. Physical explanations and imitations of such choice have been given. We may notice especially those set forth by the present author (:02) in extension of certain experiments of Rhumbler. A drop of chloroform is placed in the bottom of a watch-glass of water, and with fine tweezers pieces of various substances are brought in contact with its surface. Some are at once taken in; others are not, or are thrown out if forced into the drop. Glass, sand, dirt, wood, gum Arabic, and chlorate of potash are rejected; shellac, paraffin, styrax, and hard Canada balsam are accepted. The selection or rejection depends upon the relative amount of adhesion between the solid object on the one hand and the chloroform and water on the other. Those which adhere more strongly to the chloroform than to the water are taken in; others are rejected.

These experiments show how choice might occur in an organism; they do not show how it actually occurs in Amœba. Food-taking is usually, as we have seen, not accompanied by adhesion between Amœba and the food, so that choice of food cannot be explained as due to the fact that some substances adhere while others do not.

Rhumbler ('98) has given a physical imitation of the taking in of a food body and of later giving off the undigested residue (defecation). A rod of glass covered with a thin layer of shellac is taken in by a drop of chloroform (as a result of adhesion). The shellac is dissolved off by the chloroform and the glass rod is then thrown out, since the chloroform does not adhere to it. This imitation, like the others, loses much of its force in view of the fact that food-taking is not usually due to adhesion and that substances which do not adhere are taken as food; defecation cannot then be explained as due simply to lack of adhesion.

In all the imitations thus far we find that the physical factors at work cannot be considered the same as those that are acting in Amœba. The imitations are such only in purely external features. There exist certain imitations, however, in which this has not been proved to be the case. Thus, Rhumbler ('98) found that when chloroform drops are placed in water, the water gradually passes into the chloroform, collecting in minute globules, which later gather in a larger drop. This larger drop is finally given off to the outside. This process Rhumbler considers analogous to the formation and discharge of the contractile vacuole in Amœba. The present author (:04) has described imitations of certain movements of the pseudopodia in Amœba, produced in liquids partly covered with a solid layer; these are hardly of sufficient general interest to be detailed here. The most striking experiments which can still be considered with some degree of probability to indicate the factors really at work in certain processes occurring in the Rhizopoda are undoubtedly Rhumbler's imitations of the production of Difflugia shells. Since these deal with an organism closely related to Amœba, they may be described here.

The experiments may be performed as follows: Chloroform is rubbed up with fragments of glass in a mortar until the glass is reduced to the finest dust. Then with a pipette drawn out to a small point drops of this mixture of chloroform and glass are injected into water. At once the grains of glass come to the surface of the drops so formed and arrange themselves in a single layer, without chinks or crevices, exactly as in the shell of Difflugia. The chloroform drop is thus covered with a shell

having a striking resemblance to that of Difflugia. In place of chloroform, linseed oil or other oils may be used. The drops must then be injected into 70% alcohol, since the oil would float on water.

The factors at work in the formation of the "artificial shells" are diffusion currents within the chloroform, the adhesion of the bits of glass to its surface, and the action of surface tension in arranging and fitting together the bits of glass. Studies of the process by which the shell of Difflugia is formed at the time of division of the animal seem to indicate that the same factors may be at work in the living organism. (See Rhumbler, '98, p. 289.)

Reviewing our results, we find that few of the experimental imitations of the activities of Amœba stand before a critical comparison with what actually takes place in the animal. Such comparison shows in almost every case that the factors at work in the imitations are essentially different from those acting in Amœba. In particular, almost all the imitations based on local changes in surface tension break down completely.

What are we to conclude from this fact as to the part played by surface tension in vital phenomena? The tendency has been of late to attribute more and more of a rôle among life processes to surface tension. Amœba has been the chief place where the important part played by surface tension seemed really demonstrable; the movements, the reactions to stimuli, the taking of food, and the choice of food, were all attributed to this and closely related factors. With the demonstration of the complete failure of surface tension to account for the phenomena that were chiefly relied on to prove its importance, the supposition that it plays an immensely important rôle in life processes loses much of its weight. Surface tension may of course, in a more refined way than was supposed for Amœba, still play the large rôle in vital phenomena that some attribute to it. In the meshes of Bütschli's protoplasmic meshwork, or in the muscle fibrillæ (Bernstein), it may perhaps do what is demanded of it. Possibly the study of surface tension is still the most promising field for detection of the physical factors underlying life processes. But the surface tension theory must come to us shorn

of the trophies of its prowess, — its supposed full explanation of most of the activities of Amœba, — and bearing instead the record of a complete defeat.

What positive results of value have the physical imitations of vital activities in Amœba to show? As we have seen, there are still two or three of these that may really give us a clue to the factors at work in the vital processes; at least this has not yet been disproved. Beyond this the positive results are of a very general character. The imitations show that a drop of fluid might, through physical factors, show locomotion, move toward certain agents and away from others, and exhibit choice in the taking in of certain substances and the rejection of others. But they do not show specifically through what physical factors the activities are as a matter of fact brought about in Amœba or any other particular organism.

The chief value of most of the attempted physical imitations is that of a trial. The method of trial and error is a method of progress in science as elsewhere. In these imitations a definite explanation of the phenomena is put on trial. The "trial" consists in a more careful study of the phenomena in question; it is as an inspiration to such study that the imitations are of great value. If as a result the explanation given is recognized as "error," that is in itself an advance; this particular trial will not need to be made again. Continued application of this method of trial and error must result finally either in the discovery of the real factors at work, or in the recognition that we are dealing with a new class of factors not found in physics.

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BIBLIOGRAPHY.

Bernstein, J.

1900. Chemotropische Bewegungen eines Quicksilbertropfens. Arch. f. d. ges. Physiol., Bd. 80, pp. 628–637.

Bütschli, O.

'90. Experimental Imitations of Protoplasmic Movement. Quart. Journ. Micr. Sci., vol. 31, pp. 99–103.

'92. Untersuchungen über mikroskopische Schäume und das Protoplasma. Leipzig. 234 pp., 6 plates.

GAD, JOHANNES.

'78. Zur Lehre von der Fettresorption. DuBois Reymond's Arch. f. d. Physiol., Jhrg. 1878. pp. 181–205. Taf. 2.

HERRERA, A. L.

'98. Sur le protoplasma synthétique et la force vitale. Bull. Soc. Zool. France, vol. 23, pp. 118–120.

'98a. Sur la manière de produire certains mouvements amiboides par un dégagement d'acide carbonique. Bull. Soc. Zool. France, vol. 23, pp. 128–130.

JENNINGS, H. S.

:02. Artificial Imitations of Protoplasmic Activities and Methods of demonstrating them. Journ. Appl. Micr. a. Lab. Methods, vol. 5, pp. 1597–1602.

:04. The Movements and Reactions of Amœba. Contributions to the Study of the Behavior of the Lower Organisms, No. 6. Carnegie Institution of Washington, D. C., Publication No. 16.

LANG, A.

:01. Lehrbuch der vergleichenden Anatomie der wirbellosen Thiere. Zweite Auflage, zweite Lieferung: Protozoa. Jena. 311 pp.

LE DANTEC, F.

'94. Études biologiques comparatives sur les Rhizopodes lobés et réticulés d'eau douce. Bull. Scient. de la France et de la Belgique, T. 26, pp. 56–99.

LEIDY, J.

'79. Fresh-water Rhizopods of North America. Rep. U. S. Geol. Survey of the Territories, vol. 12, 234 pp., 48 pl.

QUINCKE, G.

'79. Ueber Emulsionsbildung und den Einfluss der Galle bei der Verdauung. Arch. f. d. ges. Physiol. Bd. 19, pp. 129–144.

'80. Ueber periodische Ausbreitung von Flüssigkeitsoberflächen und dadurch hervorgerufene Bewegungserscheinungen. Sitz. ber. d. kgl. preuss. Akad. d. wiss. z. Berlin, Bd. 34, pp. 791–804.

RHUMBLER, L.

'98. Physikalische Analyse von Bebenserscheinungen der Zelle. I. Bewegung, Nahrungsaufnahme, Defäkation, Vacuolen-Pulsation und Gehäusebau bei lobosen Rhizopoden. Arch. f. Entw.-Mech., Bd. 7, pp. 103–350.

'99. Allgemeine Zellmechanik. Merkel und Bonnet's Ergebnisse der Anatomie und Entwicklungsgeschichte, Bd. 8, pp. 543–625.

THE INFLUENCE OF THE MUTATIONS OF THE PLEISTOCENE LAKES UPON THE PRESENT DISTRIBUTION OF CICINDELA.

H. F. WICKHAM.

WITH the propagation of the late theories of life-zones founded upon temperature conditions, has come about a neglect of those considerations, of a more obscure though not less important nature, which we must recognize if we are to attain anything more than a superficial understanding of geographical distribution. The zonal theory as expounded by some of its more steadfast adherents has the apparent advantage of simplicity and moreover appeals directly to the 'practical man' since it is without doubt correctly assumed that most of our cultivated plants as well as numerous wild ones are limited to certain belts which are more or less closely coincident with the isotherms. The theory works well with agriculture in general, but it only imperfectly expresses the truth if we apply it to the natural distribution of Coleoptera on this continent. By natural, I mean original, in the sense of not being modified through the agency of civilized man; for cultivation and settlement have been potent factors in changing the range of numerous species, often resulting in the rapid extermination of the most characteristic types of a district and their replacement by others. Barriers which a few years ago were amply sufficient to prevent the intermingling of life of two nearby regions become no longer effective and the Faunæ and the Floræ become contaminated by the encroachment of strangers. Irrigation changes the nature of entire counties, lakes are drained, mountains are denuded of their forests and can no longer support the life which has been theirs for thousands of quiet years.

While it has been known for many years that the geological history of a given region has exercised a profound influence upon the present Fauna and Flora; while the effects of the Glacial

Epoch upon the life of this and other countries have long been recognized and carefully studied so that numerous distributional phenomena due thereto have thus been referred to their proper cause; and although modern lines of insect migration are being mapped and their relative importance determined, there is nevertheless a vast amount of detail to be worked out in order that certain local problems may be understood. It is with one of these local problems that we have now to do.

Some years ago, as the result of several seasons' collecting in the Great Basin, I became convinced that the distribution of certain species of Coleoptera therein occurring could not be accounted for by the theory of zonal arrangement of life, but apparently had as ultimate cause some condition or combination of conditions which belonged to the geological rather than the present history of the area under discussion. With the aim of testing this belief, further collections were made and all available data bearing upon the matter were collated, in order that it might be seen whether or not the above conclusion rested upon tangible grounds.

The Great Basin is a vast area of interior drainage, lying between the Wasatch Mountains and the Sierra Nevadas. The climate is arid, the soil in general desert, the vegetation such as characterizes regions of like nature in other parts of the world, being marked by the preponderance of a few species of dry dwarfed shrubs and the absence of forests except on certain higher mountain ranges which ridge the basin here and there. Since none of the rivers rising within the basin empty into bodies of water outside the limits, one of the most common methods of introduction of extra-limital species — by migration along the line of a water-course — is eliminated, and the fauna is not exposed to this source of modification. The two great mountain chains which form the eastern and western rims have acted as barriers to free interchange of inhabitants with the districts lying beyond, though some have doubtless crossed the passes from time to time. The southern boundary is less abruptly limited, so that those species which are suited to desert tracts may readily enter from that quarter, while the northern rim is made up of the series of hills that mark the divide between the Great Basin and the Columbia River drainage system.

We have here, then, a great enclosed region which, though comparatively open to migrations from the north and south, is nearly closed against encroachment from the east and west except in those cases where man may be conceded to have been a factor. We should expect the more characteristic forms to show extensive north and south distribution or that they may be confined to the basin and the more accessible adjoining areas. Some species no doubt originated, as such, within the limits of the basin proper, and I believe that, in some cases at least, we can determine which these are. It is with certain forms of this nature — that is to say with true indigenes — that we have now to deal.

Two types of littoral beetles may be said to be very characteristic of the Great Basin and to be dependent upon the peculiar conditions that occur there in the way of saline and alkaline flats in connection with springs and lakes. These are the Cicindelæ of the *echo* type and the species or subspecies of Tanarthrus which belong with *T. salicola*. Neither of these genera is confined to the basin, Cicindela being of wide distribution and evidently of southern origin, while Tanarthrus is not known outside of the southwestern United States. Besides the forms of this latter genus described from the lake shores of the Great Basin, a few species of somewhat different aspect are known to occur in saline spots in California and Arizona. The species of Bembidium of the *henshawi* type have also, in my opinion, attained their present specific structures within the limits of the Great Basin and are not to be considered migrants from the outside. For the present, I prefer to leave out of the discussion all of those Coleoptera not directly connected with the existence of alkaline and saline lakes, since the problem of their dispersal or distribution is different, in some respects, from that concerning the littoral forms and needs a separate body.

I am prepared to go farther than the simple statement that we can correctly indicate certain species as having arisen, as such, within the limits of the Great Basin. I believe it is also possible to show that some of these have been inhabitants of the region for long periods of time, and that in the course of their existence they have been played upon by conditions which arose

as the consequence of geological changes; that we can point out the modifications which have taken place in the species and, to a considerable extent, we can trace the geological phenomena which are the fundamental or underlying causes of the modifications. Of course not all species will be equally affected by changes in their environment, nor will the modifications necessarily be parallel. Minute differences in the organic structures of insects indicate a probable diversity of physiological characters, and varying physiological activities may well modify such details as patterns of coloration or even the colors themselves.

As an example of an insect which has, in all probability, had its range determined and its specific characters modified by a series of geological changes, the history of which is not too remote and therefore fairly well known, we may take that aggregate of forms of Cicindela described under the names *C. echo* Casey and *C. pseudosenilis* W. Horn. These are without doubt modifications of one type; in fact they are so closely related as to be separable only in series. They are also very close to *C. willistoni*, and are ranked as races thereof by Dr. Walther Horn. However, the exact status of these names, specific or subspecific, does not concern us at present; the fact remains that these forms are closely related and may well have come from a common stock. *Cicindela fulgida*, to which *willistoni* was formerly referred as a variety or race, is readily separable by the thickly haired front. It may perhaps be an older offspring of the same stem.

The ways in which the beetles differ from one another may be briefly outlined, in order that the reader may understand the relationships and the better appreciate the account of the variations of each. It must be borne in mind that the descriptions refer more especially to series of specimens than to individuals, unless definitely stated to the contrary.

Cicindela fulgida Say. Easily separated from the allied species by the front being thickly hairy. The color is usually more coppery red, though specimens occur at Lincoln, Nebraska, in which the ground color is nearly black. Markings moderate, rather narrow as a rule, the middle band not expanded along the margin (or but very slightly so), the humeral lunule very oblique

behind. This species belongs especially to the broad strip of plains lying to the eastward of the Rocky Mountains. It is known from Wyoming, Colorado, Kansas, Nebraska and New Mexico, but has not been reported from Central America nor from Old Mexico.[1]

Cicindela willistoni Leconte. A little stouter than *C. fulgida*, the color much less metallic. The front is sparsely haired; these hairs are readily lost, but the group of large punctures from which they spring may always be made out with little difficulty. Markings broader, the humeral lunule and median band always united along the margin; the apical lunule, also, usually, but not always, connected on the outer edge with the expanded marginal portion of the middle band. The tip of the humeral lunule (in those specimens in which it is free) is much less oblique than in *C. fulgida*. This insect is known only from the beaches of small lakes near Medicine Bow, Wyoming, where it was taken first by Dr. Williston, next by Mr. Warren Knaus and lastly by myself. I am not certain which of the little lakes was visited by Dr. Williston. He gives the locality Como Lake, but the usage of the village is not uniform and it may have been any one of three small lakes which lie within about twenty miles of one another. Mr. Knaus and I visited the one near the old station of Aurora, now several miles from the track. He calls it Como Lake,[2] while I have followed the prevailing custom of the villagers in speaking of it as Aurora Lake.

Cicindela echo Casey. Form of body nearly that of *C. willistoni*. Color brownish with an obscure purplish or coppery overcast. Front very sparsely hairy, the hairs being so readily removed that most specimens show only the punctures whence they originate. Markings usually rather narrow, the humeral lunule not or but slightly oblique at tip, middle band attaining the margin, usually but slightly dilated thereon but occasionally reaching the humeral lunule though not quite attaining the apical one which is complete. My series from Great Salt Lake (the original locality), most of which I collected at Saltair, in

[1] It is not included in Dr. Walther Horn's List of the Cicindelidæ of Mexico, *Jour. N. Y. Ento. Soc.*, Vol. 11, p. 213.

[2] *Entomological News*, Vol. 13, p. 147.

June, shows quite a good deal of variation in the markings, the changes chiefly affecting the middle band. The marginal portion of this band is variously developed so that it may reach quite to the humeral lunule and almost to the apical one, or it may not be expanded at all. The discal part may be quite rectangularly or very obliquely bent near the middle and the terminal knob-like appendix may be abruptly formed and angularly bent from the stem or it may appear simply as an enlargement, without being noticeably deflected at all. A set from Humboldt Lake, Nevada, taken by myself in June, while not identical with the Saltair forms, shows a range of variations almost exactly corresponding thereto, all of the important features of the one being duplicated in the other.

On the shores of Honey Lake, near Amedee, California, I took a fine series of Cicindela which I refer, for convenience, to *C. echo*, though they are not typical. The form is nearly the same and the ground colors are about alike, but the Amedee specimens almost entirely lack metallic gloss and the surface sculpture of the elytra is notably shallower. The Amedee beetles also differ, as a species, from the Saltair specimens in the broader markings, the greater obliquity of the median band (the terminal knob less deflected), and in the expansion of this band along the margin so as to connect broadly with the humeral lunule. The apical lunule is free in all of my specimens. One individual is entirely blackish, except that each elytron bears two small spots, one of which represents the anterior portion of the humeral lunule, the other the posterior part of the apical.

Cicindela pseudosenilis Walther Horn. Green, shining, a few varying to brownish or reddish. Form of body as in *C. echo*. Front of head sparsely hairy. The elytral markings are very close to those of the Saltair *echo;* the middle band does not show a distinct tendency to spread along the margin in any of my specimens, so that it is not connected with nor closely approximated by the apical and humeral lunules. The chief variations are those exhibited in the descending portion of the middle band, for though this band is usually rectangularly bent the terminal knob shows numerous modifications. In some

specimens this knob is largely developed though not hooklike, in others it disappears entirely, so that the descending part of the band is of nearly uniform size to the tip. None of the specimens in my series show a strong tendency towards the *willistoni* type of marking, the lead to that form going through *C. echo*. But some of the *pseudosenilis* approximate the Saltair *C. echo* so closely that if they were mixed they could scarcely be separated again. The shores of Owens Lake, in southeastern California, are the only definitely known haunts of the true *C. pseudosenilis*, though Dr. Howard writes me that in the National Museum is a single specimen said to have been taken by Mr. Coquillet in Los Angeles County — not very far distant. None of the other Californian collectors have found it in this latter locality, however. I found it in great abundance about the overflow of a spring on the upper beaches of Owens Lake, but none occurred in the immediate vicinity of the bitter waters of the lake itself.

Now that the variations of the insects have been described, we must turn again to the geological records and see what can be said of the early conditions of the country they inhabit. The geology of the Great Basin has been worked out by Dr. G. K. Gilbert,[1] and Dr. Israel C. Russell,[2] the results of their labors appearing in two fine volumes from which the main geological items used in this discussion are compiled. We find that in the early Pleistocene the basin held two great freshwater lakes: Bonneville, covering the greater part of western Utah and a small portion of eastern Nevada and southern Idaho, and Lahontan, occupying an extensive area in western Nevada and eastern California. Between them lay a broad plateau or divide, forming a watershed, the hydrographic basins of the lakes being contiguous. Both of these lakes were of irregular shape, Lahontan being especially so, with numerous arms and bays extending up narrow, flooded valleys. Each lake had two great periods of high water, which had been preceded by times of drought and desiccation, the second stage of flood being higher than the first. These times of plenty correspond to the two

[1] *Lake Bonneville.* Monographs of the U. S. Geological Survey, I, 1890.

[2] *Geological History of Lake Lahontan.* Monographs of the U. S. Geological Survey, XI, 1885.

glacial epochs of the Sierra Nevadas, though the climate is supposed to have been only moderately humid and rather cold. The increase in the size of the lakes is not ascribed to the melting of the glaciers, though this must have added considerably to their volume, as the ice cap was not large enough to furnish so much water. While Lake Lahontan seems not to have overflowed, Lake Bonneville broke through the barrier to the north and found an outlet to the sea by way of the Columbia River basin.[1] The desiccation of the lakes during the dry times is thought to have been more complete than at present.

The relation of our modern lakes to those of Pleistocene times is principally that of occupying the same area; that is to say, the bodies of water now existent have, in the main, been formed since the old lakes dried up, and are not to be considered remnants left by incomplete evaporation, since in the latter case the waters must have been much salter than they are. An exception may perhaps be made of Great Salt Lake, the evidence being inconclusive; and I have no data of this nature concerning Owens Lake and Mono Lake, which never formed part of these two larger bodies, but were separate even during the high-water periods of the Pleistocene. The littoral Fauna may easily have been preserved, even through times of great drought, by clustering about the edges of springs. In this way, even to-day, we know that some are carried over; for example, this very *Cicindela echo* flocks on the damp ground in the vicinity of the little springs about the edge of the now dried-up Humboldt Lake. Many springs are of a far more permanent nature than the shallow lakes into which they discharge, and I think that we may safely assume that they lasted, in many instances, through the times of most complete desiccation.

Now let us consider the relation of existing lakes (which have been examined for material for this paper), and those of ancient times, in order to see what opportunity the beetles have had for differentiation through isolation. I have visited Great Salt Lake, Utah Lake, Humboldt Lake, Honey Lake, Walker Lake,

[1]This may possibly account for the present occurrence in the Columbia district of such widely distributed Great Basin species as *Cicindela hæmorrhagica* and *Saprinus estriatus*.

Owens Lake and Mono Lake, and found *Cicindela echo* or *C. pseudosenilis* at all but three — namely, Utah, Mono and Walker. I cannot definitely assert that the species, in some of its forms, is absent from all of these three, but we have no evidence to show that it occurs there. Mono Lake may perhaps lie at too great an altitude for the insect to flourish, or it may never have been introduced into the district. It is possible that a more extended search may yet disclose some form of it there, my visit having been a hurried one and productive of no Cicindela whatever, though *C. pseudosenilis* and *C. hæmorrhagica* must have been flying in abundance at Owens Lake, distant about a hundred miles. Walker Lake has been twice visited by me with the special object of looking for some form of *C. echo*, but I took only *C. hæmorrhagica* and a variety of *C. oregona*, both in plenty. I hope that if any entomologist has the opportunity, he will visit the flats at the upper end of the lake, in the vicinity of the mouth of the river, since I have noticed that the colonies are sometimes confined to a limited area and may easily be missed. It will be well also to examine the neighborhood of the large spring said to exist near Wabuska; it dates back to considerable antiquity and may yield something interesting. Utah Lake has been visited by several entomologists at different times, and it seems that if *C. echo* occurs there it should have been met with before this.

These three lakes which have failed to yield material after exploration may be left out of the rest of the discussion. Of those which have been productive, Owens Lake has been distinct for a vast period, having, as we have seen, been separate even during the greatest extension of the others. Great Salt Lake was a part of Bonneville, while Humboldt Lake and Honey Lake lie in the ancient bed of Lahontan. The small bodies of water in Wyoming, which harbor *C. willistoni* were of course not included in either and had no communication therewith.

Looking again at the beetles, we find:

(a) The Owens Lake form, which has probably been isolated since (at least) early Pleistocene times, is sufficiently well differentiated to have been separated by systematists as a distinct species, though this view is no longer held.

(b) The form from Honey Lake, on the extreme western border of the old Lake Lahontan, is also well differentiated, though not in the same way. This lake is extremely shallow and evanescent, having dried up at least twice within the memory of the present generation, and has no doubt been separated from the main body of the old lake since a comparatively early period in the second great decline in size of the latter. The beetles live about the seepage on the lake beach that comes from the hot springs a few hundred yards distant. While it is impossible at present to point out the details which lead to variation in any one direction, it is evident that local conditions, aided by long isolation, have so modified this form that it is now readily separable, in series, from those taken elsewhere.

(c) The specimens from Humboldt Lake, farther to the east, are more of the type of typical *echo*, differing but little from the series taken at Great Salt Lake, Utah, whence the species was originally described. While the Humboldt colony must have been separate from the latter for a great length of time, it has been comparatively little differentiated therefrom. The reason for this cannot now be assigned. It may be that the local conditions requisite to incite variation were not present, or perhaps the two colonies have simply varied along parallel lines. Though isolation is unquestionably favorable to differentiation, it does not follow that every isolated colony must differ from every other. It is well known that with certain species of Cicindela some colonies produce mostly specimens of one type, others will produce those of another, while a third will be composed of a mixture of both, with all the intergrades.

(d) The form from Great Salt Lake, to which the name *C. echo* is properly applied, is not like that from Owens Lake nor that from Honey Lake, though closely approached by the specimens from Humboldt Lake.

(e) On the shores of the small lakes in Wyoming, we have *C. willistoni*, a closely related form occurring (as far as we know) nowhere else, which according to geological evidence can scarcely have had any communication with the Great Basin colonies during Pleistocene times. I am inclined to look to a still more remote date for the cause of this phenomenon, and con-

sider *C. willistoni* a survivor of an early stock which, during the Tertiary period, inhabited the present Rocky Mountain region and in all probability the adjacent districts to the east and west at the time of the great extension of the Tertiary lakes. *C. willistoni* is much better differentiated from the races of *C. echo* than those races are among themselves.

My conclusions are these: That in *C. echo* (with its several races, including *C. pseudosenilis*) and *C. willistoni*, we have two branches of a stem which were probably separated by some of the orographic movements which gave rise to the upheaval of the Wasatch and Rocky Mountains. That this stem form was a littoral species and the branch remaining in the Great Basin was carried over the interval between the dissolution of the Tertiary lakes and the appearance of the great Pleistocene lakes by clinging to the borders of springs and other bodies of water. That with the growth of Lake Bonneville and Lake Lahontan and the contemporaneous filling by water of the smaller basins, it spread over the whole habitable area between the Wasatch and the Sierras. The subsequent desiccation of the greater part of the Lahontan and Bonneville basins left a series of smaller lakes of varying permanence and more or less complete isolation. Local conditions, acting on the members of colonies of the beetles thus separated from their neighbors, have given rise to variations of different kinds and certain of these variations have been preserved and accentuated through this isolation. As a consequence, we have the phenomenon of local races, strongly or slightly marked according to the strength of the conditions exciting variability and to the comparative degree of isolation of the colony after a certain character had made its appearance. Owens Lake and Honey Lake, having been long since separate from the larger bodies and presumably subjected to different conditions, climatic and otherwise, because of their proximity to the Sierras, have at length produced upon their shores racial types which are easily distinguished from each other and from the forms found farther east.

If the species of Cicindela used in illustration were alone in presenting the general phenomena noticed, one might well doubt the sufficiency of the evidence adduced in support of the foregoing

conclusions: and as the matter stands, I am well aware of the circumstantial nature of much of it and of the many possibilities of wrongly interpreting the facts. However, I have been collecting and studying other species of littoral Coleoptera in the Great Basin, with a view to further prosecution of the problem, and find much in corroboration. It is evident that the same general law is followed in the variations of Tanarthrus, and I hope also to demonstrate a parallelism in certain Carabidæ and Histeridæ which are associated with it.

State University of Iowa,
Iowa City, March 19, 1904.

CONTRIBUTIONS FROM THE ZOÖLOGICAL LABORATORY OF THE MUSEUM OF COMPARATIVE ZOÖLOGY AT HARVARD COLLEGE. E. L. MARK, DIRECTOR.— No. 154.

A SIMPLE APPARATUS FOR AËRATING LIQUID SOLUTIONS.

S. O. MAST.

In studying the effect of dilute and concentrated solutions of sea water on marine algæ it became necessary to aërate the solutions in order to keep them fresh. For this purpose a very simple piece of apparatus was devised. The apparatus was used slowly to concentrate or dilute the solutions as well as to aërate them. It has now been in continuous operation for over three months and has proved to be so effective, to require so little care, and to be so easily made, that a brief description of it may be useful to others.

The general structure of the apparatus will be readily understood by referring to the accompanying figures. It will only be necessary then to discuss a few details of its structure and the principles on which its operation depends.

The aërating tubes used in the experiments mentioned above are 90 cm. long and 4.5 mm. in diameter (inside measure), which is constricted to 0.5 mm. at a point 7 cm. from the upper end. The capillary siphon is 0.75 mm. in diameter; the solution in the culture jar is 27 cm. deep. It will readily be seen that, since the aërating tube is much larger than the capillary siphon, if both are to be constantly full the solution must flow much more slowly in the tube than in the siphon.

Owing to the action of gravitation, however, the motion of the solution tends to accelerate as it falls, and therefore tends to flow faster in the aërating tube than in the siphon; so that the solution in the tube as it flows through the constriction is broken into very short columns separated by small bubbles of

air, which incidentally aërates the solution. Several of these columns unite, forming larger ones as they flow down the tube, as do the bubbles also. The relative lengths of these

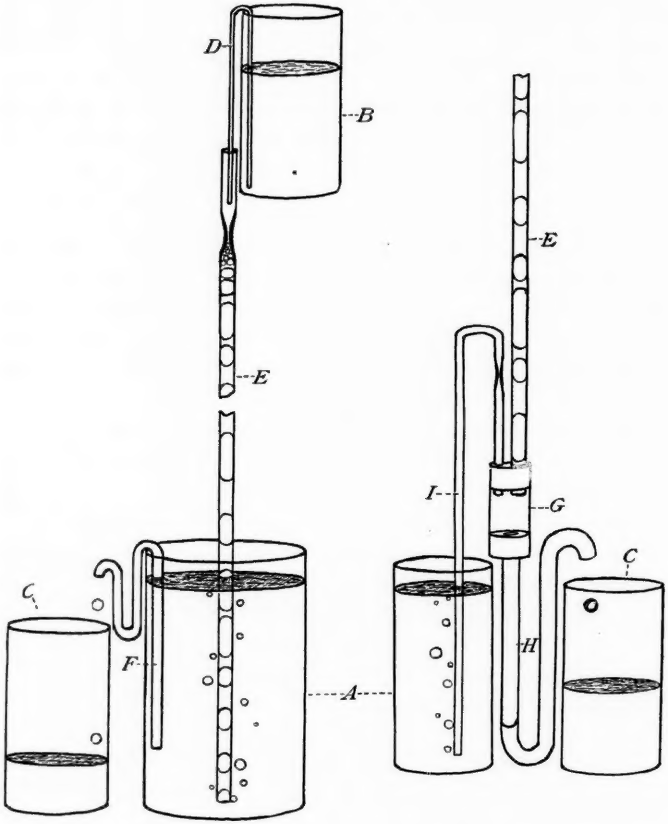

FIG. 1. FIG. 2.

FIG. 1. — An aërating apparatus in which the liquid used to aërate flows into the culture jar. FIG. 2. — A similar apparatus in which the liquid does not flow into the culture jar. *A*, a culture jar, *i. e.*, a jar containing a solution to be aërated; *B*, a supply jar; *C*, an overflow jar: *D*, a capillary siphon; *E*, an aërating tube; *F*, a constant-level siphon; *G*, *H* and *I*, accessories to the aërating tube.

columns of solution and spaces of air depend upon three factors: (1) The difference between the diameter of the capil-

lary siphon and that of the aërating tube, (2) the length of the aërating tube, and (3) the depth of the solution in the culture jar. All that is necessary in order to increase the amount of air, as compared with that of the solution in the tube, is to increase either the diameter or length of the aërating tube or to decrease the depth of the solution in the culture jar.

If the diameter of the tube is increased and the flow kept constant it is clear that more air must be taken in to fill the increased space due to the enlargement. But as the diameter increases the adhesive force between the walls of the tube and the solution in it decreases, as compared with the cohesive force of the solution, so that when a certain diameter is reached the bubbles of air break through the columns of solution and thus can no longer be forced to the bottom of the tube in the culture jar. As a matter of fact, the maximum limit of diameter in the case of water is practically about 4.5 mm. Further, if the rate of flow in the aërating tube be in any way increased while that in the siphon remains constant, more air will be required to keep the tube full, just as in case of an increase in diameter. The râte of flow in the tube, however, varies directly with the length of the tube; and since there is no theoretical limit to the possible length of the tube, the amount of air compared with that of solution can be theoretically increased indefinitely. The depth of the culture solution is really a function of the length of the aërating tube. In order to overcome the pressure of the culture liquid and force the air out at the bottom of the aërating tube, it is necessary to have a column of solution in the tube *above* the level of the solution in the culture jar slightly greater than the air space in the tube *below* that level. Consequently the portion of the tube which is below the level of the solution in the culture jar and enough of it above that level to contain as much solution as there is air below, have nothing to do with increase in acceleration due to gravitation, for they simply balance each other, and therefore these parts are not effective in increasing the amount of air introduced. This being true, it will readily be seen that increasing the depth of the culture solution has the same effect as decreasing the length of the aërating tube, and that therefore the deeper this solution, other things being equal, the less will be the air forced through.

The purpose of the constriction in the aërating tube is merely to break up the column of solution in the tube. If this were not thus broken up it would accumulate until it became slightly greater than the air spaces in the tube below the level of the culture fluid and then would suddenly flow down, forcing the air out with a rush, after which it would again accumulate, flow down, etc. This is just what happens if the constriction is not small enough in comparison with the size of the capillary siphon. A few experimental trials, however, will be sufficient to enable one to decide on the proper relative sizes of the two. No definite instruction can be given with reference to this since the diameter of the siphon must vary with the diameter and length of the aërating tube and with the depth, specific gravity and viscosity of the culture solution. In general the constriction should be somewhat smaller than the siphon.

In some forms of apparatus[1] the lower end of the aërating tube is bent on itself so as to project upwards in the culture solution and a small piece of sponge is then pressed rather tightly into this bent free end, or the tube may be drawn out into a capillary ending. It is claimed that the sponge, especially, breaks up the air into very small bubbles. This is undoubtedly true, but it has been found that in the apparatus represented in Figures 1 and 2 the pressure required to force the air through the sponge is so great that the value of this adjunct is questionable.

The most efficient and simplest method discovered to break up the air bubbles is as follows: Cut off the lower end of the aërating tube square, grind it quite flat, and let it rest on a firm piece of rubber, leather, or wood on the surface of which a considerable number of radiating grooves has been made. The piece of rubber rests on the bottom of the culture jar and the tube is placed over the point whence the grooves radiate. The grooves in any event must be narrow. Their depth should depend upon the weight of the aërating tube. If the tube is heavy it will sink into the surface upon which it rests, and therefore under such conditions the grooves must be deeper than if the

[1] See H. Lenz. Verbesserung an den Durchlüftungsapparaten der Seewasser-Aquarien. *Zool. Anzeiger*, 1879, Jahrg. 2, pp. 20, 21.

tube is light. Although by this device the bubbles are not broken up as much as they can be by using a piece of sponge forced into the end of the tube, this method has the decided advantage of requiring much less pressure, and there is also much less danger of clogging the tube than if a sponge is used.

In making the aërating constriction the tube should be heated, without being drawn out, until the walls fall in, as this causes them to become much thicker and consequently stronger than they otherwise would be.

It is much better to use a capillary siphon than a larger tube drawn out to a capillary ending; first, because a capillary siphon never needs to be filled, for when the supply jar is filled to within about 1 *cm.* of the top capillary attraction will fill the siphon and start it running; secondly, because a large tube drawn out at one end is much more readily clogged than a small one of equal diameter throughout.

The constant-level siphon (*F*) should be unquestionably large enough to drain off the solution as fast as it comes into the culture jar, but not much larger; neither should its outer end be more than a few centimeters lower than its highest point, for if it is the decrease in pressure at the highest point causes sufficient increase in vapor pressure of dissolved gases to cause them to be thrown out of solution, to collect at this point, and thus to clog the siphon.

The principles of operation in the second apparatus, that, represented in Figure 2, are in all respects similar to those discussed with reference to the apparatus represented in Figure 1. The upper end of the aërating tube, the capillary siphon, and the supply jar are the same as represented in Figure 1.

The chamber *G*, which serves to separate the air from the liquid, can be readily made by cutting off a test tube. It should be about 1.5 cm. in diameter and 4 or 5 cm. long. It must of course be air-tight. Ordinary corks soaked in paraffin will serve very well to close the ends.

The tube *H* should be at least 5 mm. in diameter, slightly larger than the aërating tube proper, *i. e.*, large enough to prevent air being forced through it with the solution. Its length must be such that its outer end is somewhat farther above its

lower bend than the outer end of the tube *I* is below the surface of the solution in the culture jar; for if it is not the air will pass out through it instead of through the culture solution.

The tube *I* serves to convey the air from the chamber *G* into the culture solution. It may be of any size, length or form. The lumen through the constriction in it is very small; though not absolutely necessary, it serves to cause a more steady flow of air. A rubber tube with an adjustable pinch-cock might serve this purpose still better.

All that is necessary to operate either apparatus described, is to pour the solution from the overflow jar into the supply jar from time to time. The frequency required in this operation depends of course upon the size of the jars and the diameter of the capillary siphon. If, as in the experiment mentioned above, 4-liter jars and a 0.75 mm. siphon are used, a transfer once in three days will be quite sufficient.

In closing I wish to thank Dr. E. L. Mark for furnishing material which made the experiments referred to above possible, and for valuable criticism of the manuscript of this article.

SPIRE VARIATION IN *PYRAMIDULA ALTERNATA*.

FRANK COLLINS BAKER.

I. Introduction.

The object of the present investigation has been to ascertain by quantitative means the amount of variation in the same species of a pulmonate mollusk from several localities. For this purpose the shell of the common species, *Pyramidula alternata*, has been selected, as that species shows a large amount of variation in the form of the shell, particularly in the height of the spire.

Among the mollusks little biometric work was done previous to the year 1898. Since that time this group of animals has been receiving marked attention and several exhaustive papers have been published, notably those by C. C. Adams on Io and C. B. Davenport on Pecten. These papers, however, have dealt with marine or fresh water forms; in this investigation the biometric study has been applied to an air breathing land mollusk.

II. Material.

The material used in this investigation, *Pyramidula alternata* Say, was secured from the following localities:

1. Rochester, New York, on the steep hillside of the "Pinnacle" and the banks of the lower Genesee River. This locality is heavily wooded and there is a large accumulation of fallen logs and the ground is covered by a rich, black loam. Collected by the writer.

2. Auburn, New York, in damp, low, flat woodlands. Collected by Dr. Howard N. Lyon.

3. Bowmanville, near Chicago, Illinois, in flat woodlands. The timber is large and heavy, the ground is strewn with fallen

logs and the soil is a rich, black loam. Collected by the writer. The shells studied are not of uniform size, although they are nearly all adult measuring from twelve to twenty-four millimeters in diameter. The young shells of this species always have a flat or nearly flat spire, and as they would materially affect the results they were excluded.

In *Pyramidula alternata* we find a good example of variation caused by individual environment. The species lives for the most part under started bark, in crevices and under flat-lying tree trunks; hence its shell varies with its abode. For example, a specimen living between the "started" bark of a tree and the tree trunk, the space being very narrow, measured 23×11 mill., the height being about 48 per cent. of the width, while another specimen living under a fallen tree trunk measured 15×13 mill., the height being about 87 per cent. of the width, or 39 per cent. more than the first example. These specimens were from the same locality and from adjacent trees. Their habit of crowding into narrow crevices and between the bark and the tree trunk has caused this species to become one of the most variable of land shells as regards the form of the shell.[1]

On account of the extreme variability it was thought that a quantitative study of material from several rather widely separated localities would produce results of some interest. This species has a wide geographic range, being found throughout the eastern and central parts of the United States and Canada. Its western limit is said to be Minnesota.

III. Method of Obtaining Quantitative Data.

To obtain a variation index the diameter and altitude of the shell was measured in millimeters and the altitude divided by the diameter; *i. e.*, $\frac{\text{altitude.}}{\text{diameter}}$ The per cents. obtained in this way provide the shell index. In the diagrams the individuals or classes having the same per cent. are indicated on the horizontal line and the number of specimens in these classes (the frequencies) are indicated on the vertical line.

[1] See *Nautilus*, Vol. 10, p. 63, for a good article on this subject by C. C. Ormsbee on "Influence of Environment upon the Form and Color of Helix alternata."

The number of specimens available for this study has not been as large as is desirable in investigations of this kind; but as the three lots are of about the same number the results will not be materially affected.

In the tables of data the per cents. are indicated by a numerator and the individuals or frequencies having the same per cent. is noted as a denominator.

IV. Discussion of Data.

The Rochester Shells.

Figure 1.

The shells from Rochester show a rather wide range of variation, as is seen in Fig. 1, which is strongly trimodal. The most

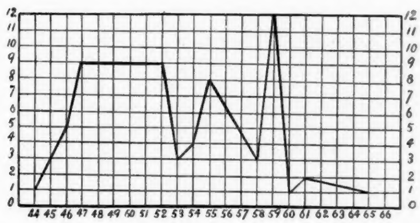

Fig. 1.— Rochester shells. Variation curve of 67 specimens.

peculiar aspect of this curve is the broad mode from 47 to 52 per cent., the frequencies being 9. The two sharp modes are 55 with a frequency of 8 and 59 with a frequency of 12. The variation is from 44 to 65 per cent. The data for Fig. 1 is shown in Table A.

Table A.

44	46	47	50	52	53	54	55	58	59	60	61	65
1	5	9	9	9	3	4	8	3	12	1	2	1

The number of shells examined was 67.

The Auburn Shells.

Figure 2.

The Auburn shells are not as variable as those from Rochester, a fact shown by the greater regularity of the curve, which

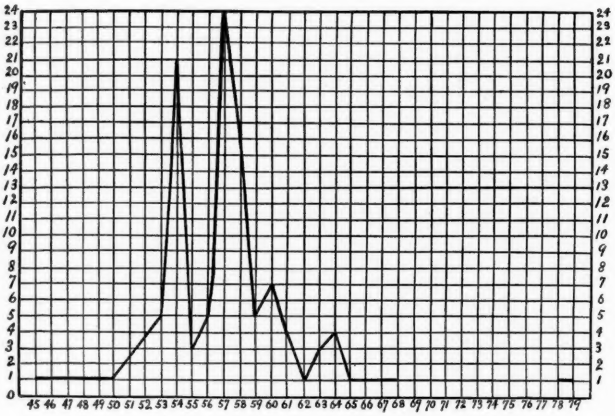

FIG. 2. — Auburn shells. Variation curve of 104 specimens.

is practically bimodal, the minor mode being at 54 per cent. with a frequency of 21 and the major mode at 57 with a frequency of 24. The data for this curve is shown in Table B.

Table B.

45	50	53	54	55	56	57	58	59	60	61	62	63	64	65	66	68	79
1	1	5	21	3	5	24	16	5	7	4	1	3	4	1	1	1	1

The number of shells examined was 104. The range of variation is from 45 to 79 per cent.

The Bowmanville Shells.

Figure 3.

The Bowmanville shells are the most variable of the three lots, the curve showing a marked multimodal tendency, which

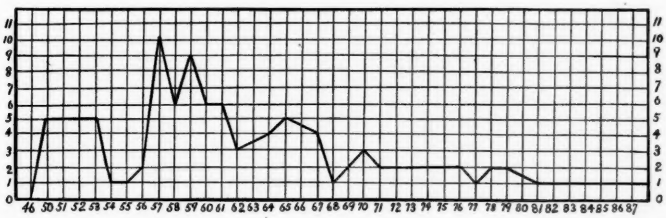

FIG. 3. — Bowmanville shells. Variation curve of 85 specimens.

always stands for extreme variability. The range of variation is from 46 to 87 per cent. There are four modes of prominence, at 50–53, 57, 59 and 65, with frequencies of 5, 10, 9 and 5, respectively. It will be noted that the curve for the Bowmanville shells is very similar to that of the curve for the Rochester shells, the peculiar broad mode being present in each. The data for this curve is shown in Table C.

Table C.

46	50	53	54	55	56	57	58	59	60	61	62	64
1	5	5	1	1	2	10	6	9	6	6	3	4
65	67	68	70	71	72	76	77	78	79	81	87.	
5	4	1	3	2	2	2	1	2	2	1	1	

The number of specimens examined was 85.

V. Comparison of the Three Localities.

Figure 4.

In comparing the three localities it will be noted that the Bowmanville and Rochester shells resemble each other very

closely in the form of their curves, which is quite different from

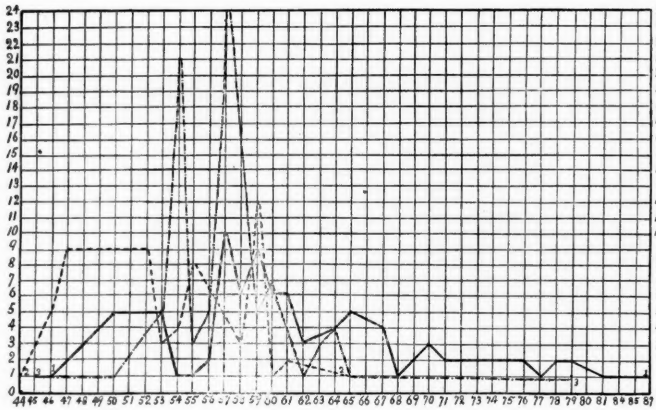

FIG. 4. — Comparison of the three localities. 1. Bowmanville. 2. Rochester. 3. Auburn.

the Auburn curve, which is very symmetrical, showing a smaller amount of variation. The major mode for the three localities is about the same, standing as follows:

Bowmanville	57 %.[1]
Rochester	59 %.
Auburn	57 %.

The mean per cent. for the three localities is as follows:

Bowmanville	65.1 %.
Auburn	59.7 %.
Rochester	54.1 %.

This shows that the Bowmanville shells have relatively the highest spires, while the Rochester shells have the lowest spires. The widest variation is found in the Bowmanville shells, where the extremes are 46 and 87 per cent.

[1] 100% would mean that the diameter and height were the same; hence the per cent. shows the relation of height to diameter.

Geographically the western shells show a wider range of variability than do the eastern shells. With one exception (Auburn 79%) the eastern shells have the per cent. of spire elevation between 44 and 68, while those from the west range between 46 and 87, the per cents. between 68 and 81 being numerous.

One of the most noticeable features in the curves as plotted in this paper is their tendency to assume a multimodal form. This is clearly shown in the individual diagrams, but stands out prominently in the comparison of the localities (Fig. 4). This is, of course, indicative of great variability.

From the study of these three lots of shells we may conclude that the western *alternata* has a higher shell, on the average, than does the eastern form, and that it shows a much larger amount of variation in spire elevation. It would be very interesting to have curves plotted from other localities, east and west, to ascertain whether their results would coincide with the conclusions of the present paper.

BIBLIOGRAPHY.[1]

BAKER, FRANK C.
Rib Variation in Cardium. Amer. Nat. XXXVII, 481–488, 1903.

BAKER, FRANK C.
The Digitations of the Mantle in Physa. Bull. Chi. Acad. Sci., II, No. 4, 1901.

BATESON, W.
On Some Variations of Cardium edule apparently correlated to the Conditions of Life. Phil. Trans. Roy. Soc. London, 180, B, 297, 1889.

BIGELOW, R. P. AND RATHBURN, ELEANOR P.
On the Shell of Littorina litorea as Material for the Study of Variation. Amer. Nat., XXVII, 171, 1903.

BUMPUS, H. C.
The Variations and Mutations of the Introduced Littorina. Zoological Bulletin, I, 247, 1898.

[1] This bibliography contains some of the more important papers bearing on the variation of the Mollusca, from a biometric standpoint; the list is not exhaustive.

DAVENPORT, C. B.
On the Variation of the Shell of Pecten irradians Lamarck from Long Island. Amer. Nat., XXXIV, 863, 1900.

DAVENPORT, C. B.
Comparison of Some Pectens from the East and West Coasts of the United States. Mark Anniversary Volume, article VI, 121, 1903.

DAVENPORT, C. B.
Comparison of Pecten opercularis from Three Localities of the British Isles. Proc. Amer. Acad. Arts and Sci., XXXIX, 123, 1903.

DIMON, ABIGAIL C.
Quantitative Study of the Effect of Environment upon the Forms ot Nassa obsoleta and Nassa trivitata from Cold Spring Harbor, Long Island. Biometrica, II, 24, 1902.

DOWNING, ELLIOTT R.
Variation in the Position of the Adductor Muscles of Anodonta grandis. Say. Amer. Nat., XXXVI, 395, 1902.

MAYER, A. G.
Some Species of Partula from Tahiti. A Study in Evolution. Mem. Mus. Comp. Zool., XXVI, 117, 1902.

THE CHICAGO ACADEMY OF SCIENCES.
June 4, 1904.

FOSSIL PLUMAGE.

C. R. EASTMAN.

PRESERVATION of avian remains in the fossil state is necessarily of very rare occurrence, and extraordinarily so, if fossilization takes place in marine sediments. Cases of the latter description presuppose the creature either to have perished at sea, or to have been swept out at a distance from the land as a floating carcass without having been destroyed by predaceous animals. The body must have sunk to the bottom before decomposition had advanced far enough to disrupt the skeleton and scatter the plumage. Burial by fine sediments must have followed almost immediately, in order that the body be preserved intact. And mineral replacement of the organic tissues must have proceeded in a wonderfully subtle manner, transforming the most delicate particles into stone without obliterating their microscopic structure.

Supposing a dead bird to have reached the bottom in a tolerably complete condition, the feathers naturally become loosened and scattered with decomposition of the skin, and the least current is liable to sweep them away except they become entangled and covered by the sediment at once. If the material happens to be a fine calcareous ooze, the feathers may leave in it an exceedingly delicate impression, or, in the rarest cases of all, their structure may become replaced molecule for molecule by mineral matter, generally calcareous or carbonaceous.

Chance, controlling thus absolutely the fate of this class of remains, goes away after sealing them up in the rocks to remain hidden for ages; but may peradventure come back again, and disclosing them to the light of day, permit them to fall into the domain of scientific investigation. Great as is the miracle, it has actually happened a few times, as witness the two complete individuals of Archæopteryx that are known, and one of Hesperornis, with their plumage preserved. Scarcely less

interesting and remarkable are the complete examples found in lacustrine and fluviatile deposits, the most perfect in our own country being Palæospiza from the insect-bearing shales of Florissant, Colorado, and Gallinuloides from the Green River Eocene of Wyoming. In the former the plumage is preserved, in the latter it is wanting.[1] Skeletons nearly as perfect as these have also been described from fresh-water deposits of the south of France and elsewhere in Europe.

But it is fossil plumage from marine deposits with which this article is especially concerned. The feathers of Archæopteryx are too well known to require more than a mere mention of their occurrence, and those of Hesperornis, recently made known from the Kansas Cretaceous, are still fresh in the minds of students.[2] There is yet another marine horizon from which feathers have been obtained, these constituting, however, the only indication of avian life which exists in the formation. This is the Upper Eocene limestone of Monte Bolca in the Veronese, famous for nearly four centuries on account of its remarkable fish and plant remains. But as for the occurrence of detached feathers to the exclusion of other remains, it should be remembered that marine and shore-birds are constantly shedding them, and hence, if circumstances favoring preservation are equal, they are likely to be numerically more abundant than bones.

Owing to their excessive rarity and wonderful preservation, it is not surprising that the few feathers thus far obtained from Monte Bolca should be objects of considerable interest. In the early days of palæontology, no little rivalry was created over the acquisition of the first specimens brought to light, one having been found in 1777, and another some twenty years later, both

[1] A solitary feather from the Green River shales of Wyoming was discovered by F. V. Hayden in 1869, and noticed by Marsh in the *American Journal of Science* for 1870 (vol. 49, p. 272). Detached feathers are also known from the Florissant locality in Colorado; the Lower Miocene of Ronzon, near Puy-en-Veday; the Upper Miocene lignite of Rott, near Bonn; and from the Upper Miocene lacustrine deposits of Oeningen, Switzerland. Good examples from the last-named locality, and of Ratite feathers from the Quaternary of New Zealand, are preserved in the Museum of Comparative Zoölogy at Cambridge.

[2] Williston, S. W., *Kansas Univ. Quar.* Vol. 5, p. 53, 1896. —Marsh, O. C., *Amer. Journ. Sci.* [4] vol. 3, p. 347, 1897.

being in counterpart. These two specimens, which are now preserved in the Paris Museum of Natural History, were described and figured in the early part of the last century by Faujas-St.-Fond,[1] but not without misgivings lest his readers be inclined to doubt their avian nature. The names are given of four professors at the Museum who agree with the author in his conclusions, and it is observed that with reference to one of the feathers, that "on ne sauroit la confondre avec certains *fucus* qui ont quelques rapports apparens avec des plumes, parce que celle-ci a ses barbes garnies d'autres petites barbes." This is the only statement which is given in regard to the finer structure, and the latter is not illustrated in the figures. Both of these feathers, it may be added, are of the pennaceous, and not of the plumulaceous variety.

Except for a casual mention by Milne Edwards[2] of his having seen one or two fossil feathers in Verona, where they are still on exhibition in the Public Museum, no other references occur in literature to this sort of remains from Monte Bolca. It may therefore be of interest to examine the figure which is given herewith of a specimen recently acquired by the Museum of Comparative Zoölogy at Cambridge, along with a fine suite of fish-remains from a famous old Veronese collection. This is a small contour feather, only 1.5 cm. long, but remarkable for its perfect preservation of details. It is possible to distinguish each separate barb of the symmetrical vane, and even the barbules along either side of the branches.

Fossil Carinate feather from the Upper Eocene of Monte Bolca, Italy. $\times \frac{3}{1}$.

[1] Faujas-Saint-Fond, B. Mémoire sur quelques fossiles rares de Vestena Nova dans le Véronais. *Ann. Mus. d'Hist. Nat.* vol. 3, pp. 18–24. 1804.

[2] Milne Edwards, A. *Oiseaux Fossiles de la France*, vol. II., p. 544, 1871.

The barbules appear relatively shorter, coarser, and less closely spaced than those in the body-feathers of recent Carinates, and the apex of the vexillum is more pointed. The shaft not being prolonged at the base, it is probable that the specimen is complete in itself, and not the tip of a larger feather. No inferences are warranted regarding even the remote affinities of the form it belonged to, beyond that chances favor its having been a shore bird of small or moderate size. Although the beds were undoubtedly laid down under deep-water conditions, the presence in them of crocodilians, chelonians, and plant remains indicates that the Bolca locality was not far removed from land at the time these strata were deposited. It deserves to be stated that, according to Walther, the Solnhofen lithographic stone in which Archæopteryx occurs was deposited within a coral island lagoon.

NOTES AND LITERATURE.

ZOÖLOGY.

"**An Introduction to Vertebrate Embryology**" by Dr A. M. Reese[1] is "the result of a need that the author has felt, for some years, for a concise text-book of embryology that described the development of both the chick and the frog" (Preface, p. v). It is questionable if such a need has been generally felt in the presence of existing treatises on embryology, though they may be more "cumbersome and expensive" books than Dr. Reese's. There is something to be said in favor of students becoming acquainted, at first hand, with standard works such as the text-books of Balfour, Hertwig, Marshall, and Minot.

To give a satisfactory account of the development of both the frog and chick within the space limits of a book like Dr. Reese's, the author must be a master of the subject and, equally important, he must be a master of the art of expression in written language. It is unfortunate that Dr. Reese's book does not do justice to its author's knowledge. The fundamental defect of the book — a defect which overshadows good qualities — lies in poor presentation of the subject, and, in a book which does not offer new material, form is the all-important thing, so long as facts are not violated. The account of the development of the optic nerve may be cited as an example of the quality of description. "It is sometimes stated that the *optic nerve* is formed by the hollow stalk of the optic cup; but it is probable that it is formed by an outgrowth of cells from the retina, this outgrowth extending along the optic stalk to the brain, and forming the fibres of the optic nerve. The growth of these fibres may have, as has been mentioned, something to do with the formation of the choroid fissure" (p. 181). What, in the light of this paragraph, is the manner of development of optic nerve fibres? The account of the development of the chick begins with the sentence, "The egg of the chick (Fig. 33) is of large size, ovoid in shape and usually some-

[1] Reese, A. M. *An Introduction to Vertebrate Embryology Based on the Study of the Frog and the Chick.* New York, G. P. Putnam's Sons, 1904. XVII + 291 pp., 84 figures.

what larger at one end than at the other" (p. 90). (If the egg of the "chick" were not ovoid, what would its form be?) Then follows what apparently is a description of the egg at the time of laying. In the course of this description it is stated that the yolk exhibits on one side "a small, whitish circle, the *blastoderm* or *cicatricula*" (p. 91). The next paragraph tells us that "Although of so large a size, the yolk of the hen's egg is a single cell, its great size being chiefly due to the large number of yolk granules which it contains "(p. 92). Fortunately, the last paragraph of the section on "The Egg" explains, as if by an afterthought, that "The preceding is a description of the egg at the time of its laying" and that "The statement that the yolk is a single cell is really true only from the time it leaves the ovary until it is fertilized, or until a short time after fertilization, when segmentation begins" (p. 93). Even then we are left in doubt as to the precise time when the egg ceases to be a single cell. It does not tend toward conciseness to make an incorrect statement and then add a paragraph to explain what is "really true."

In the accounts of the visceral apparatus of both frog and chick, an indiscriminate use of the terms *gill*, *branchial*, and *visceral*, as applied to the several arches and clefts, leads to hopeless confusion. It is doubtless by an oversight that the author states that the ectodermal auditory invagination of the frog gives rise to the lining of the middle ear (p. 43). It is a surprise to find the terms *somatopleure* and *splanchnopleure* applied to the parietal and visceral layers of mesoderm respectively. The use of the incorrect plurals "diverticulæ" and "lumena," an apparent failure to appreciate that *nares* is a plural, and reference to nascent organs as rudiments are comparatively unimportant matters. The figures, mainly from Marshall, Duval, and Minot, are well reproduced, but their arrangement in relation to the text could be much more convenient.

A book such as Dr. Reese has proposed should lay down in a few firm bold strokes the main outlines of the subject. Unimportant details should be omitted, important details must be adequately treated. The account must proceed in an orderly constructive way, always complete so far as it has progressed, like the development it portrays. There must be such unfailing accuracy and such clearness of statement that misconception is impossible. If Dr. Reese's book is not an unqualified success, it is because the author undertook a very difficult task.

H. W. R.

A Hermit's Wild Friends.[1]— The first impulse of a reviewer on reading this book is to rage and to utter vain things. There is something peculiarly irritating in the cock-sureness and the condescension of ignorance; there mingles, no doubt, with our zeal for the defense of truth a little of the wrath of the orthodox prophet against him who would lead the people after false gods and therefore after a false prophet. If it were only a question of the scientific world, it would be hardly necessary to pay any attention to the book, but the reviews quoted by the publishers show how easily the general press are mislead. The Hermit is hailed as a second Thoreau, or put before Thoreau, since he "spares us Thoreau's philosophy." One reviewer admits that there is much "out-of-the-way information," but is convinced that it all bears "the stamp of truth." Another reviewer assures us gravely that the book never goes "beyond the observed facts." It is rather against an unscrupulous publisher and irresponsible reviewers that our wrath should be directed; the Hermit's sins are those of ignorance and vanity; the publisher's are those of greed.

The book purports to give true and detailed records of intimacies with wild animals of the Gloucester woods, where the author has lived for years. He has numbered among his intimates, song sparrows, chewinks and chickadees, squirrels, mice and crows. It will only be necessary to give an extract taken almost at random to show the character of the book. The "Hermit" has found (p. 187) a crippled sparrow and has been feeding him in his camp in the woods. "The fourth day, while I was feeding him, an old chewink hopped to the loaf of bread [always put out for the birds], and called him. The sparrow did not respond at first, but after awhile hopped over to see what the chewink wanted. He seemed surprised to find the bread, and began at once to help himself. The chewink called him into the bushes. *I suppose he intended to give him an introduction to his family.* The next day the sparrow came into the dooryard alone. He made for the bread and did not look at me. I tried to catch him, but he hopped into the bushes, apparently filled with terror. I think that old chewink had told the sparrow that I was a very bad man. The old fellow might have been jealous, and had frightened the young sparrow, so that he would fly from me in wild alarm. The next time the sparrow visited the yard the

[1] Walton, Mason A. *A Hermit's Wild Friends.* Boston, Dana Estes & Co. [1903]. pp. 1–304.

chewink was with him. They departed together, and three days later I saw the sparrow near the old barn..... *It was evident* that the chewink had piloted him three-fourths of a mile to his friends..... How did the chewink know where to take the sparrow?" How indeed? The italics are the reviewer's and this passage is commended to the critic who could say that the book never went "beyond assured facts." When we add that the illustrations are in keeping with the text we have done all that is possible to put the public on their guard against this book.

R. H.

The Sino-Australian Continent.—The existence of this continent, first assumed by Neumayr for the Jurassic period, and which was accepted by various subsequent writers for the Cretaceous, and upward in the geological scale to the beginning of the Tertiary, apparently needs restriction with regard to its duration. It now is rendered more or less probable that it was not present at all in the Jurassic period. Lately G. Bœhm[1] has demonstrated that, in the region of the Moluccas, Mesozoic marine deposits of European type are largely developed, and are chiefly represented by various horizons of the Jurassic series. Bœhm draws the conclusion, "it becomes apparent that a Sino-Australian Jurassic continent, as conceived by Neumayr, did not exist."

On the other side, deposits of Cretaceous age are absent or scarce in this region, so that this old continent might have existed at least during a part of the Cretaceous period. Bœhm does not discuss this question, but we must bear in mind that zoögeographical facts positively demand a connection of Australia with eastern Asia, and all evidence tends to show (see H. von Ihering, C. Hadley. H. A. Pilsbry, A. E. Ortmann, M. Weber) that this connection was a broad and important one in pre-Tertiary times, while, during the Tertiary, it became more irregular, and was subject to many changes which amounted frequently to complete interruption, which latter condition prevails at present. The restriction of the Sino-Australian continent to a certain part of the Cretaceous times consequently would meet the postulates both of geology and zoögeography.

A. E. O.

[1] Geologische Ergebnisse einer Reise in den Molukken, in: *Compt. Rend. 9. Congr. Geol.*, Wien., 1904.

Origin of the Large Mammals of North America.—M. Grant[1] discusses the old continental connections of North America with the Old World and with South America. Most important is his idea about the old "Beringian connection" between northeastern Asia and northwestern America, which, according to him, was not a continuous one in time, as generally accepted (from the upper Cretaceous to the lower Pleistocene). Grant believes that it existed in the lower Eocene, lower Oligocene, middle Miocene, upper Pliocene and lower Pleistocene, but that it was interrupted chiefly in the middle and upper Eocene, upper Oligocene and lower Miocene. The evidence supporting this assumption is not very convincing, since in part it may be founded only upon a deficiency in our knowledge of the fossil Mammals both of the Old and the New World. Moreover, the geographical distribution of marine animals does not support this view, at least as far as it refers to the older Tertiary. There is hardly any trace of an exchange of faunas between the northern Pacific and the northern Atlantic by way of the Arctic basin during earlier Tertiary times, the similarities in the faunas of these oceans generally being clearly indicative of a very recent connection of them. There is either no resemblance at all, or very close affinity of forms generally amounting to specific identity, the latter cases being found among forms that are apparently circumpolar cold-water types of recent origin.

It shall not be denied that there are a few cases of allied or even identical species in both oceans belonging to more temperate climatic conditions (for instance, resemblances of Japanese and Mediterranean forms) which might possibly indicate a former interruption of the Beringian bridge in the beginning of the later half of the Tertiary, but this point needs further elucidation.

A. E. O.

PALÆONTOLOGY.

Walther's Solnhofen Fauna.[2] — One of the most philosophical discussions of extinct Faunæ is this essay by Dr. Walther, which forms part of the Hæckel Anniversary Volume. The geological

[1] *8th Ann. Rep. New York Zool. Soc.*, 1904.

[2] Walther, J. *Die Fauna der Solnhofener Plattenkalke, bionomisch betrachtet.* Jena. 1904.

evidence is interpreted as demonstrating the extension of coral reefs throughout the shallow sea covering Central Europe in late Jurassic time, which was a period of oscillation. The fine calcareous sediment interbedded with lithographic stone, for which the district about Solnhofen is famous, represents the infilling of a lagoon, outside of which the coral limestone carries a totally distinct fauna. The peculiar mixture of land and marine organisms, the occurrence of large trunks of trees and seaweed with roots, the interbedding of apparently wind-blown material, and the tracks of undoubted air-breathing animals, are among the facts which indicate that the bottom of the lagoon was barely below tidewater, and probably was even exposed at times. Creatures straying into the lagoon and becoming entrapped there, or volant forms like insects, Pterodactyls and Archæopteryx, which met their death in the paste-like, rapidly accumulating sediment, were covered before any injury had been done to their bodies through decomposition or other causes, the most delicate structures being perfectly preserved. Although the variety of forms is large, yet Solnhofen fossils are surprisingly rare as compared with the majority of horizons, and a great many species are known only by one or two individuals; several important groups are not represented at all, and on the other hand, a large percentage of species is restricted to this locality. There appears to be no room for doubting that the assemblage is an accidental one, and this vast cemetery gives us a unique but by no means typical reconstruction of the late Jurassic fauna.

Karl Alfred von Zittel.— Of the numerous biographical sketches which have appeared of the great master of palæontology this recent memorial of Pompeckj, pupil, associate and intimate friend of the late Geheimrath, is the most complete, and most satisfactory. This is not a eulogy of von Zittel, but a plain and sufficient account of his career, with his achievements mentioned in such a way that they speak for themselves, and with the light so distributed upon his personal traits, his ambition, energy, concentration — and above all upon his aptitude as a teacher, helpful, inspiring and commanding of respect,— that his character is revealed naturally before us without addition or subtraction, as must be acknowledged by anyone who had the good fortune to know him well. Dr. Pompeckj has told us

[1] Pompeckj, J. F. Karl Alfred von Zittel: Ein Nachruf. *Palæontographica*, vol. L., 1904.

in measured and dignified language much that is good to know and to remember in connection with the life-work of one of the torch-bearers of science, but there is one respect in which we would like to have been told more. Zittel as a teacher, text-book writer, ardent collector and museum administrator, Zittel as an investigator thirsting for scientific discovery — in all these capacities he is presented to us; but enough has not yet been said in regard to him as a philosopher, as a theorizer upon the vast store of empirical knowledge of which he was the possessor. He was an excellent systematist, and the faculty of coördination was developed in him to a remarkable degree. Though he discovered no new laws of natural history, yet he had faith in the discovery of others, and he believed in certain principles and methods of drawing philosophical conclusions, as sincerely as he disbelieved in certain others, nor did he always insist upon his own personal judgment, often deferring to the opinions of colleagues in whom he had confidence. On such matters as these we should eagerly welcome more light.

BOTANY.

Maple Sap Flow.[1]— This paper, by Messrs. Jones, Edson, and Moore, and edited by J. H. Hills, Director of the Agricultural Experiment Station of Vermont, is unusual in two ways. It is a very good paper, giving the carefully considered results of experiment and observation sufficiently extended to justify general conclusions. In the second place the paper is unusual for it is the first on this subject since Clark's papers in 1873 and 1874.[2] As I have said elsewhere,[3] it is surprising that American botanists at the Agricultural Experiment Stations in the states where maple-syrup and maple-sugar making is an important industry have not carefully studied the phenomena, at least from an economic standpoint. The present paper is written both from the economic and from the physiological standpoint, and the plant physiologist will find in it data which he

[1] *Bulletin Vermont Agric. Exp. Station*, No. 103, Dec., 1903.

[2] *Report Mass. Agric. Coll.*, 1873-4; *Report Mass. State Bd. Agric*, No. 22, 1874.

[3] *Text Book of Plant Physiology*, 1903.

has long wished to have. The paper is of such length (184 pages, 8vo) that even an abstract may easily be too long for this journal.

After an introduction, stating the importance of the maple-sugar industry, the process of sugar-making, and former investigations, the authors proceed to describe their plan of work and the scope of their investigations. A few pages are given to the structure and general physiology of the maple. In sixty pages the authors discuss (1) the water and gas contents of the maple at different seasons, comparing it with other trees; (2) pressure, positive and negative, at different seasons, in different parts of the tree, and the direction of pressure and sap movement; (3) temperatures, comparing internal with external. It is to be hoped that this study of external temperatures will be supplemented by further ones. The authors studied only air temperatures, but it is obvious that the temperatures of the soil must have at least an equal, if not a greater, bearing on the phenomena of sap flow in the spring than the air temperatures. As others have shown, the roots begin to be active much earlier than the aërial parts of trees and shrubs growing in the temperate zone. This early resumption of active life in the roots, and the energetic absorption of water from the soil, depend more directly on soil temperatures than on air temperatures. Hence, if we are thoroughly to understand the process of periodic sap flow, we must know all the conditions, not merely those in the air and in the aërial parts of a tree. It may not be too much to suggest also that studies of the water-content of soil and air before, during, and after sugaring time would be a valuable addition. This is intimated by the authors, though the subject is not pursued further.

The remaining seventy pages are occupied by a discussion of economic problems and by tabular reports of weather conditions, etc.

G. J. P.

The Journals.— *The Botanical Gazette*, May:— Sargant, "The Evolution of Monocotyledons"; Smith, "The Nutrition of the Egg in Zamia"; Opperman, "A Contribution to the Life History of Aster"; Cardot and Thériot, "New or Unrecorded Mosses of North America"; Livingston, "Physical Properties of Bog Water"; Rose, "William M. Canby"; Ramaley, "Anatomy of Cotyledons."

The Bryologist, May:—Grout, "The Peristome—VI"; Holzinger, *Rhacomitrium Flettii*, n. sp."; Holzinger, "A Bryologist's Glimpse into Geological History"; Harris, "Lichens — Collema and Lepto-

gium"; E. G. Britton, "Notes on Nomenclature — III"; Grout, "The Specific (?) Value of the Position of the Reproductive Organs in Bryum"; and a number of short notes by various persons.

The Fern Bulletin, April: — Curtiss, "The Fern Flora of Florida"; Eaton, "The Genus Equisetum in North America—XVII"; Clute, "New or Rare Ferns from the Southwest"; Eaton, "Preliminary list of Pteridophyta Collected in Dade Co., Florida, during November and December, 1903"; Kalbfleisch, "*Polystichum acrostichoides* and some Insects that infest it"; Burnham, "Ferns of Ann Arbor, Mich."; Clute, "Raynal Dodge" (with portrait); and short notes by various persons.

Journal of Mycology, March: — Morgan, "A New Melogramma"; Cockerell, "Some Fungi Collected in New Mexico"; Dudley and Thompson, "Notes on Californian Uredineæ and Descriptions of New Species"; Kellerman, "Ohio Fungi, Fascicle IX"; Kellerman, "Minor Mycological Notes — III"; Kellerman, "Index to Uredineous Culture Experiments, with List of Species and Hosts for North America — I" (concluded); Kellerman, "Notes from Mycological Literature—IX"; and Kellerman, "Elementary Mycology."

Journal of the New York Botanical Garden, May:—MacDougal, "Botanical Explorations in the Southwest"; Broadhurst, "The Protection of Our Native Plants."

The Ohio Naturalist, May: —Claasen, "List of the Mosses of Cuyahoga and Other Counties of Northern Ohio"; and Schaffner, "Deciduous Leaves."

The Plant World, April: — Safford, "Extracts from the Note Book of a Naturalist on the Island of Guam — XVII"; Broadhurst, "Nature Study as a Training for Life"; Nehrling, "The Beginning of Spring in Florida — I."

The Plant World, May: — Morris, "The Bush Morning Glory"; Safford, "Extracts from the Note Book of a Naturalist on the Island of Guam — XVIII"; Nehrling, "The Beginning of Spring in Florida—II."

Rhodora, May: — Parlin, "Some Casual Elements in the Flora of Western Maine"; Pease, "Preliminary Lists of New England Plants—XV"; Sanford, "Occurrence of *Verbena stricta* and *Helianthus mollis* in Mass."; Hill, "Note on the Polygamy of Chionanthus"; Woodward, "Two Noteworthy Plants of New Haven, Ct.";

Robinson, "*Stellaria glauca* established in the Province of Quebec"; Knight, "Some Plants New to the Flora of Maine"; and Eaton, "Note on *Equisetum pratense.*"

Proceedings of the Society for the Promotion of Agricultural Science, Vol. 25: — Hansen, "Possibilities of the Western Sand Cherry"; Pammel, "Some Unusual Fungus Diseases in Iowa during the Summer of 1903"; King, "Promising Methods for the Investigation of Problems of Soil and Plant Physiology, and Some Lines of Investigation to which they are Adapted."

Bulletin of the Torrey Botanical Club, April: — Peck, "New Species of Fungi"; Evans, "Hepaticæ of Puerto Rico — IV"; Morgan, "Polarity and Regeneration in Plants."

Bulletin of the Torrey Botanical Club, May: — Nelson, "New Plants from Wyoming — XV"; "Code of Botanical Nomenclature" (in three languages); Watterson, "The Effect of Chemical Irritation on the Respiration of Fungi."

Torreya, April:—Underwood, "Early Writers on Ferns and their Collections— II"; Rusby, "William Marriott Canby"; MacKenzie, "Notes on Evening Primroses"; Cockerell, "Mutations and Ferns"; Sumstine, "A New Hydnum."

Torreya, May: — Eggleston, "A Canoe Trip on the St. Francis River, Northern Maine"; Kobbé, "Notes on the Local Flora"; and Britton, "*Viburnum molle* Michx."

Zoe, April: — Brandegee, "A Collection of Mexican Plants"; Greenman, "New Species of Mexican Plants"; T. S. Brandegee, "Palms of Baja California"; and Katharine Brandegee, "Notes on Cacteæ."

Notes. — A "Flora of Los Angeles and Vicinity," by Abrams (Stanford University Press, April 5, 1904) forms an octavo volume of 474 pages, and contains analytical keys and full descriptions of the Spermatophyta of the coast slope of Los Angeles and Orange Counties, California. The Orders are arranged in the Engler and Prantl sequence, and the Neo-American nomenclature is adopted — with synonymic citation where the generic name is unfamiliar to the ordinary reader.

A Catalogue of the Bryophyta and Pteridophyta of Pennsylvania, by the late Professor Porter, edited by Dr. Small (Boston, Ginn &

Co., 1904) forms an octavo of 66 pages. Each entry is followed by habitat and distribution data by counties.

A check-list of the higher plants of Hamilton County, Ohio, and a list of medicinal plants growing in the vicinity of Cincinnati, both by Aiken, form no. 4 of Vol. 20 of the *Journal of the Cincinnati Society of Natural History*.

A few separates of the several chapters of Vol. 5 of the publications of the Harriman Alaska Expedition, dealing with the cryptogams, have been distributed by the authors.

A dictionary of plant names of the Philippine Islands, by Merrill, forms a bulletin from the Philippine Bureau of Government Laboratories.

A paper on the flora of St. Andrews, New Brunswick, by Fowler, is published in "Contributions to Canadian Biology," — a supplement to the 32d *Annual Report of the Department of Marine and Fisheries, Fisheries Branch*, of Canada.

Fascicle 2 of Millspaugh's "Plantæ Yucatanæ," forming Vol. 3, no. 2, of the botanical series of *Publications of the Field Columbian Museum*, deals with Compositæ, by C. F. Millspaugh and Agnes Chase, and is admirably illustrated.

The first fascicle of Vol. 3 of Halacsy's "Conspectus Floræ Græcæ," recently issued, covers Lentibulariaceæ to part of Cyperaceæ.

A general comparison of the Alpine floras of Australia and Europe is given by Weindorfer in *The Victorian Naturalist* of September last.

Forbes and Hemsley's enumeration of the plants of China, etc., forming Vol. 36 of the *Journal of the Linnean Society* (Botany), has reached the 18th part, dealing with parts of Cyperaceæ and Gramineæ.

Warburg and de Wildeman have begun the publication of an account of Ficus as represented in the Congo district, in the *Annales du Musée du Congo*, the first fascicle being issued in January, 1904.

The newly established *Records of the Albany Museum*, of Grahamstown, is in part devoted to South African botany.

Part 10 of Hough's *American Woods*, comprising nos. 226 to 250, represents chiefly western and southwestern species, — perhaps the

most interesting being *Cereus giganteus.* Like earlier fascicles, this is accompanied by leaf and fruit keys and indexes for the entire issue, and a systematic account of the species now distributed.

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An account of *Colletotrichum glœosporioides* and its diseases of Citrus is published by Rolfs as *Bulletin 52* of the Bureau of Plant Industry of the U. S. Department of Agriculture.

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Fungous diseases of fruits in Michigan are discussed by Longyear in *Special Bulletin No. 25* of the Experiment Station of that State.

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CORRESPONDENCE.

To the Editor of the American Naturalist:

SIR: — Apropos of Dr. Theodore Gill's letter in the March number relative to early collections of the vernacular names of animals, it is interesting to recall that Thomas Gray, "the English poet who has written less and pleased more than any other," was an accomplished naturalist for his time, and busied himself during the last ten years of his life in compiling, amongst other notes, a voluminous catalogue of the familiar names of plants and animals. Not only the common English synonyms are given of Linné's species, but also their equivalents in more than a score of languages, some of the citations being from remote and little-known tongues.

These lists were written down by Gray in his interleaved copy of the tenth edition of the *Systema Naturæ*, and portions of them, some 25 pages in all, were published in the second volume of Mr. T. J. Mathias's edition of Gray's *Works*, which appeared in 1814. Other selections from the same source, with facsimiles of some of his drawings, have recently been published by Mr. Charles Eliot Norton, who now possesses Gray's original copy. No one can take up this little booklet[1] without feeling grateful to Professor Norton for having placed this "monument of Gray's learning and industry" within general reach. It is stated by the editor that these annotations, if printed, would form a volume at least equal in size to one of Linné's, and that the light they throw on the poet's occupations and interests during his latter years helps us to a "more just appreciation of his character and his acquisitions."

Those interested in the derivation of the common names of animals may find it worth while to consult a paper by J. W. Gibbs on the "Origin of the Names of Beasts, Birds, and Insects," published in vol. xli, of the *American Journal of Science* (pp. 32–39, 1841).

C. R. EASTMAN.

[1] *The Poet Gray as a Naturalist with Selections from his Notes on the Systema Naturæ of Linnæus* etc. Boston, Charles E. Goodspeed. 1903. pp. 67.

Nos. 451–452 were mailed September 30, 1904.